

ANL/EAD/TM-99

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# **Cost Estimate Report for the Long-Term Management of Depleted Uranium Hexafluoride: Storage of Depleted Uranium Metal**

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## NOTATION

The following is a list of acronyms, initialisms, and abbreviations (including units of measure) used in this report.

### ACRONYMS, INITIALISMS, AND ABBREVIATIONS

ABC	activity-based cost
A/E	architect/engineering
ANL	Argonne National Laboratory
DOE	U.S. Department of Energy
D&D	decontamination and decommissioning
FY	fiscal year
HEPA	high-efficiency particulate air
HVAC	heating, ventilation, and air conditioning
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
NEPA	National Environmental Policy Act
NPV	net present value
O&M	operations and maintenance
OMB	Office of Management and Budget
p.a.	per annum
PEIS	Programmatic Environmental Impact Statement
ROD	Record of Decision
SAIC	Science Applications International Corporation
U	uranium
U <sub>3</sub> O <sub>8</sub>	triuranium octaoxide
UF <sub>6</sub>	uranium hexafluoride
UO <sub>2</sub>	uranium dioxide
WBS	Work Breakdown Structure
WIPP	Waste Isolation Pilot Plant

## NOTATION (Cont.)

### UNITS OF MEASURE

ft	foot
ft <sup>2</sup>	square foot
ft <sup>3</sup>	cubic foot

in.	inch
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kW	kilowatt
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lb	pound
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m	meter
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**COST ESTIMATE REPORT FOR THE LONG-TERM  
MANAGEMENT OF DEPLETED URANIUM HEXAFLUORIDE:  
STORAGE OF DEPLETED URANIUM METAL**

by

S.M. Folga, P.H. Kier, and P.R. Thimmapuram

**SUMMARY**

This report contains a cost analysis of the long-term storage of depleted uranium in the form of uranium metal. Three options are considered for storage of the depleted uranium. These options are aboveground buildings, partly underground vaults, and mined cavities. Three cases are presented. In the first case, all the depleted uranium metal that would be produced from the conversion of depleted uranium hexafluoride ( $UF_6$ ) generated by the U.S. Department of Energy (DOE) prior to July 1993 would be stored at the storage facility (100% Case). In the second case, half the depleted uranium metal would be stored at this storage facility (50% Case). In the third case, one-quarter of the depleted uranium metal would be stored at the storage facility (25% Case). The technical basis for the cost analysis presented in this report is principally found in the companion report, ANL/EAD/TM-100, *Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride: Storage of Depleted Uranium Metal*, prepared by Argonne National Laboratory (Folga et al. 1999).

The estimated values in the main text of this document are based on the storage box design developed for the continuous metallothermic reduction process to convert depleted  $UF_6$  to depleted uranium metal, described in *Depleted Uranium Hexafluoride Management Program: The Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride*, published by Lawrence Livermore National Laboratory (LLNL 1997). This box design was used in the Engineering Analysis Report (LLNL 1997) and the Programmatic Environmental Impact Statement (PEIS) (DOE 1999) for interim storage and transport of metal billets from the conversion site to the manufacturing site, where the billets were melted and used in making casks. This design does not appear to effectively use the space available for uranium metal storage and, as a consequence, results in a larger storage area than may be needed. Another box design that would reduce the amount of void space, and thereby the total area required for storage, is described in Appendix E of ANL/EAD/TM-100 (Folga et al. 1999). Appendix A of this report provides revised cost values based on the proposed box design and serves as a sensitivity analysis for the main text.

A comparison of the net present value (NPV) for the three options for long-term storage of uranium metal is shown in Table S.1. This table also includes the revised building storage design using the proposed box design. The options are compared with the life-cycle costs

**TABLE S.1 Discounted Life-Cycle Cost for Each Storage Option (\$ million)**

Type of Storage Enclosures	UF <sub>6</sub>	U <sub>3</sub> O <sub>8</sub>	UO <sub>2</sub>	U-Metal
Aboveground Buildings <sup>a</sup>	214.48	224.99	146.59	224.99
Below-grade Vaults <sup>a</sup>	--- <sup>c</sup>	237.11	152.38	294.26
Underground Mined Cavities <sup>a</sup>	644.25	731.21	482.94	490.56
Revised Aboveground Buildings <sup>b</sup>	---	---	---	182.12

<sup>a</sup> Life-cycle cost for long-term storage of UF<sub>6</sub>, U<sub>3</sub>O<sub>8</sub>, and UO<sub>2</sub> taken from Elayat et al. (1997).

<sup>b</sup> Developed by using the storage box design proposed in Appendix E of Folga et al. (1999) .

<sup>c</sup> Hyphens indicate that the analysis was not done for those chemical forms.

provided in the LLNL report *Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* (Elayat et al. 1997) for long-term storage of three other chemical forms: UF<sub>6</sub>, uranium dioxide (UO<sub>2</sub>), and triuranium octaoxide (U<sub>3</sub>O<sub>8</sub>). A value of 7% per annum (p.a.) was applied to determine the NPV, as recommended by the Office of Management and Budget (OMB) Circular A-94, Section 4 (OMB 1992).

In general, the life-cycle cost for depleted uranium metal storage is comparable to the cost for storing the other chemical forms. The following points, however, should be noted:

1. The box design used for depleted uranium metal storage has a profound effect on the discounted life-cycle cost. The life-cycle cost for building storage, assuming a more efficient storage box design, is lower by about 19% than that of the base case (\$182.12 million versus \$224.99 million). Even greater savings could be realized with an optimized box design.
2. The life-cycle cost of storing depleted uranium metal in buildings is greater than the cost of storing the other chemical forms in buildings because:
  - A nonoptimized box design is used for uranium metal storage.
  - Utility costs during operations and maintenance are higher for storing depleted uranium metal than for storing the other chemical forms because it was assumed that continuous high-efficiency particulate air (HEPA) filtration and air ventilation (to prevent hydrogen buildup and retard uranium metal corrosion) would be needed — unlike the Engineering

Analysis Report (LLNL 1997), which assumed operations during 5% of the year.

- Capital cost items such as emergency electric generators, radiation monitoring stations, and instrumentation needed to comply with safety regulations were added for depleted uranium metal storage, but they appear to be absent in the facility designs for the other three chemical forms in the Cost Analysis Report (Elayat et al. 1997).
  - Labor costs during operations and maintenance for the other three chemical forms in the Cost Analysis Report (Elayat et al. 1997) appear to be low compared with the estimated workforce costs in the Engineering Analysis Report (LLNL 1997).
3. The life-cycle cost of storing depleted uranium metal in vaults is greater than the cost of storing the other chemical forms in vaults because:
- A nonoptimized box design is used for uranium metal storage.
  - A revised vault design is used for storage of depleted uranium metal, which allows for easy access to the vaults for inspection and removal of damaged boxes. It appears that the vault design considered in the Engineering Analysis Report (LLNL 1997) does not make provisions for these activities, which are necessary to assure safe, continued long-term storage operations.
  - Utility costs during operations and maintenance are higher for storing depleted uranium metal than for storing other chemical forms because it was assumed that continuous HEPA filtration and air ventilation (to prevent hydrogen buildup and retard uranium metal corrosion) would be needed — unlike the Engineering Analysis Report (LLNL 1997), which assumed operations during 5% of the year.
  - Capital cost items such as emergency electric generators, radiation monitoring stations, and instrumentation needed to comply with safety regulations were added for depleted uranium metal storage, but they appear to be absent in the facility designs for the other three chemical forms in the Cost Analysis Report (Elayat et al. 1997).
  - Labor costs during operations and maintenance for the other three chemical forms in the Cost Analysis Report (Elayat et al. 1997) appear to

be low compared with the estimated workforce costs in the Engineering Analysis Report (LLNL 1997).

4. The cost for storing depleted uranium metal in a mined cavity is comparable to the cost of storing the other three chemical forms because:
  - A nonoptimized box design is used for uranium metal storage.
  - Utility costs during operations and maintenance are higher for storing depleted uranium metal than for storing other chemical forms because it was assumed that continuous HEPA filtration and air ventilation (to prevent hydrogen buildup and retard uranium metal corrosion) would be needed — unlike the Engineering Analysis Report (LLNL 1997), which assumed operations during 5% of the year.
  - Capital cost items such as emergency electric generators, radiation monitoring stations, and instrumentation needed to comply with safety regulations were added for depleted uranium metal storage, but they appear to be absent in the facility designs for the other three chemical forms in the Cost Analysis Report (Elayat et al. 1997).
  - Labor costs during operations and maintenance for the other three chemical forms in the Cost Analysis Report (Elayat et al. 1997) appear to be low compared with the estimated workforce costs in the Engineering Analysis Report (LLNL 1997).

Table S.2 provides the nondiscounted life-cycle cost for each storage option and chemical form. Similar trends to those seen in Table S.1 appear in Table S.2.

The overall conclusion of this cost analysis is that the cost for long-term storage of depleted uranium metal is similar to the cost for long-term storage of the other three chemical forms. The life-cycle costs for storage of  $\text{UO}_2$  and uranium metal in buildings and mined cavities are within the -30%/+50% accuracy of the preconceptual facility design. Because the vault design for depleted uranium metal storage differs from that provided in the Engineering Analysis Report (LLNL 1997) in that it allows for inspections and removal of damaged boxes, its life-cycle cost is expected to be greater than the cost for the other chemical forms for this type of storage structure.

**TABLE S.2 Nondiscounted Life-Cycle Cost for Each Storage Option (\$ millions)**

Type of Storage Enclosures	UF <sub>6</sub>	U <sub>3</sub> O <sub>8</sub>	UO <sub>2</sub>	U-Metal
Aboveground Buildings <sup>a</sup>	782	837	531	874
Below-grade Vaults <sup>a</sup>	--- <sup>c</sup>	873	557	1,184
Underground Mined Cavities <sup>a</sup>	2,460	2,830	1,800	1,890
Revised Aboveground Buildings <sup>b</sup>	---	---	---	699

<sup>a</sup> Life-cycle cost for long-term storage of UF<sub>6</sub>, U<sub>3</sub>O<sub>8</sub>, and UO<sub>2</sub> taken from Elayat et al. (1997).

<sup>b</sup> Developed by using the storage box design proposed in Appendix E of Folga et al. (1999) .

<sup>c</sup> Hyphens indicate that the analysis was not done for those chemical forms.



## 1 INTRODUCTION

A number of options for the long-term management of depleted uranium hexafluoride ( $\text{UF}_6$ ) generated prior to July 1993 have been assessed by the U.S. Department of Energy (DOE) (DOE 1999; Lawrence Livermore National Laboratory [LLNL] 1997). These options included several choices for the chemical form of depleted uranium to be stored and three types of storage facilities. The chemical forms assessed were  $\text{UF}_6$ , uranium dioxide ( $\text{UO}_2$ ), and triuranium octaoxide ( $\text{U}_3\text{O}_8$ ). The types of storage facilities considered were aboveground buildings, below-grade vaults, and underground mined cavities.

This report addresses long-term storage of an additional chemical form — uranium metal. The cost analyses for storage of the other three chemical forms are given in the *Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* (Elayat et al. 1997) (hereafter referred to as the Cost Analysis Report) and in the unpublished backup documentation to the Cost Analysis Report, titled *Depleted Uranium Hexafluoride Management Program, Preliminary Cost Estimate — Phase I for Storage Options for Depleted Uranium Management* (Science Application International Corporation [SAIC] 1996) (hereafter referred to as the Cost Estimate Report).

To help ensure a fair comparison of costs of long-term storage of the four chemical forms, the same unit costs and unit effort per activity used in the Cost Estimate Report are used in this report, as appropriate. A review of the unit costs in the Cost Estimate Report was performed through comparison with cost engineering standards such as the *Unit Price Book* (U.S. Army Corps of Engineers 1989) and *Means Building Construction Cost Data* (Means 1997). The quantities that these unit costs and unit efforts multiply are given in the companion report ANL/EAD/TM-100, *Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride: Storage of Depleted Uranium Metal* (Folga et al. 1999), also prepared by Argonne National Laboratory (hereafter referred to as the Engineering Analysis Report — Uranium Metal).

The estimates were developed from preconceptual engineering data as well as budget-level cost quotations, where available. In the Cost Analysis Report, costs were developed in a three-phase process. In Phase I, costs of the primary contributors to capital and operating costs were developed. In Phase II, factors for other life-cycle costs that were not considered to be significant cost contributors in Phase I were analyzed. In Phase III, the costs estimated in Phases I and II were integrated to arrive at a total life-cycle cost. Typical Phase II costs include costs for site qualification, site selection, oversight/ownership fees, royalties, payments in lieu of taxes, revenues, and costs of capital. In this report, as in the Cost Estimate Report, Phase I estimates are presented. However, a total life-cycle cost could be estimated by using the Phase II costs for this option together with the cost for other options that make up a particular alternative in the Cost Analysis Report.

The estimated values in the main text of this document are based on the storage box design developed in the *Depleted Uranium Hexafluoride Management Program: The*

*Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* (LLNL 1997) (hereafter referred to as the Engineering Analysis Report) for the continuous metallothermic reduction process to convert depleted  $\text{UF}_6$  to depleted uranium metal. This box design was used in the Engineering Analysis Report and the Programmatic Environmental Impact Statement (PEIS) (DOE 1999) for interim storage and transport of metal billets from the conversion site to the manufacturing site, where the billets were melted and used in making casks. This design does not appear to effectively use the space available for uranium metal storage and, as a consequence, results in a larger storage area than may be needed. Another box design that would reduce the amount of void space, and thereby the total area required for storage, is given in Appendix E of the Engineering Analysis Report — Uranium Metal. Appendix A of this report provides revised cost values based on the proposed box design and serves as a sensitivity analysis to compare with the main text.

It should be noted that, as was the case for the Cost Analysis Report, the estimates developed in this report are intended to provide a basis for comparison of significant cost differences between the storage alternatives and are not intended to yield specific project budget estimates. To facilitate comparison, the structure of this document is patterned after the structure of the Cost Estimate Report.



## 2 MANAGEMENT SUMMARY

### 2.1 PHASE I, LEVEL V, MEDIAN COSTS

The Cost Estimate Report contains Phase I, Work Breakdown Structure (WBS) Level V, estimates of preoperational, capital, operating, and decontamination and decommissioning (D&D) costs for long-term storage of depleted uranium in three chemical forms:  $\text{UF}_6$ ,  $\text{UO}_2$ , and  $\text{U}_3\text{O}_8$ . Because the same approach is used in this report, it also contains Phase I, WBS Level V, estimates of preoperational, capital, operating, and D&D costs for long-term storage of depleted uranium as uranium metal.

Level V indicates that there are five levels to the WBS. A WBS is defined as a “product-oriented family tree division of hardware, software, facilities, and other items that organizes, defines, and displays all the work to be performed in accomplishing the project objectives.” The use of a WBS is a way to organize and estimate in a logical manner that facilitates a clearer understanding of the information. It is often used as a primary mechanism for the breakdown of costs. The first two WBS levels with the value “1.4” denote long-term storage within the overall cost approach for management of depleted  $\text{UF}_6$ ; the third WBS level denotes the type of storage enclosure (“1” for aboveground buildings, “2” for below-grade vaults, “3” for underground mined cavities); the fourth level indicates the chemical form in which the depleted uranium is stored; and the fifth level is the purpose of the cost (“1” for equipment, “2” for facilities, “3” for site, “4” for regulatory compliance, “5” for operations and maintenance, and “6” for D&D).

In the Cost Estimate Report, the fourth level denotes the chemical form by “1” for  $\text{UF}_6$ , “2” for  $\text{U}_3\text{O}_8$ , and “3” for  $\text{UO}_2$ . In keeping with this structure, a value of “4” will be used in the fourth level of the WBS for uranium metal. In the Cost Estimate Report, no costs were developed for regulatory compliance or transportation; for consistency, no costs for regulatory compliance or transportation are presented in this report. However, the total life-cycle cost for long-term storage of depleted uranium metal can be estimated by using the costs for regulatory compliance and transportation provided in the Cost Analysis Report. The WBS is illustrated graphically for aboveground buildings in Figure 2.1,<sup>1</sup> for below-grade vaults in Figure 2.2, and for underground mined cavities in Figure 2.3.

Costs are presented for three types of storage facilities — uranium metal stored in buildings, vaults, or mined cavities. Phase I, WBS Level V, median life-cycle costs for the three combinations are given Tables 2.1 through 2.3. Costs are in millions of first-quarter fiscal year (FY) 1996 dollars to be consistent with the Cost Estimate Report.

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<sup>1</sup> The figures and tables referenced in this report are placed at the end of each chapter.

Equipment costs include estimates for major components, such as cranes or straddle carriers. Equipment costs include engineering, fabrication, installation, and certification and testing at Level VI. Previous estimates for similar equipment and current cost estimation manuals and databases were used to estimate equipment costs and installation effort.

Facility costs include costs for the storage enclosures (buildings, vaults, or mined cavities) and the receiving warehouse and repackaging building. Facility costs include engineering, construction, and project management at WBS Level VI. Reported costs are based on estimates of facility support equipment (such as building heating, ventilation, and air conditioning [HVAC] and fire protection) and building structural materials (such as concrete and structural steel). As stated in the Cost Estimate Report pricing of these materials and systems was developed from previous estimates for similar structures, from current cost estimation manuals, or from historical factors developed for similar projects.

Site costs include site improvements and utilities and the site support buildings, such as the administration building and the workshop. Site costs include engineering, construction, and project management at WBS Level VI. As stated in the Cost Estimate Report, costs for site improvements and utilities are based on preliminary estimates of site clearing, grubbing, and mass earthwork. Support building costs were estimated by using estimated costs per square foot of each building based on existing data for similar buildings.

Operations and maintenance (O&M) costs include labor, materials, utilities, waste management and disposal costs, and a maintenance allowance necessary to operate the facility at design capacity for 40 years (20 years for the emplacement phase and 20 years during the monitoring and surveillance phase). D&D costs are assumed to be 10% of the sum of the equipment, facility, and site costs. As stated in the Cost Estimate Report, the median costs reflect a contingency based on a 50% probability of overrun and a 50% probability of underrun.

Table 2.4 provides a breakdown of the net present value (NPV) for the three options considered for long-term storage of uranium metal. A value of 7% per annum (7% p.a.) was applied to determine the NPV, as recommended by OMB Circular A-94, Section 4 (OMB 1992). The discounted costs for technology development (\$0.82 million) and regulatory compliance (\$18.61 million) were taken from the Cost Analysis Report. Cost components developed in Phase II and Phase III that are not included in Table 2.4 include costs for site qualification, site selection, oversight/ownership, fees, revenue, and cost of capital — cost components that are not pertinent for a government-owned facility.

As expected, the NPV for building storage is the lowest among the three storage options, with mined-cavity storage as the most expensive. The discounted costs in Table 2.4, in general, agree with those for the long-term storage of the other three chemical forms ( $\text{UF}_6$ ,  $\text{U}_3\text{O}_8$ , and  $\text{UO}_2$ ) shown in Table 4.11 of the Cost Analysis Report. The major difference is in the discounted costs for operations and maintenance. Material costs for uranium metal storage are lower due to the low cost of the wooden box (\$30) used to store the uranium metal billets. Utility costs are higher for uranium metal storage due to the assumption that the storage area would be

continuously ventilated to limit hydrogen gas retention and reduce surface corrosion of the uranium metal. Also, unlike the Engineering Analysis Report, continuous operation of the high-efficiency particulate air (HEPA) filtration system was assumed to attenuate any potential airborne releases under normal (incident-free) and accident conditions. Labor costs are higher for similar reasons. The Cost Analysis Report assumed a zero D&D cost; for comparison purposes, this analysis also applied a zero D&D cost. The actual D&D costs for the three storage options are provided in the footnote attached to Table 2.4.

For comparison purposes, Table 2.5 provides the median (nondiscounted) life-cycle cost for each storage option. It should be noted that the D&D costs have been included in this table. The costs of long-term storage of uranium metal are similar to those for  $\text{UF}_6$  and  $\text{U}_3\text{O}_8$  and more than that for  $\text{UO}_2$ . The costs of uranium metal would be lower if a more-optimized package is used for storage (see Appendix A). The current design in the Engineering Analysis Report uses a 4-ft<sup>3</sup> wooden box to store 19 uranium metal billets, each 2 in. by 3 in. by 20 in. long. Only 43% of the wooden box's volume is used for uranium metal storage. Thus, there is a potential for a 57% reduction in the size of the package containing the uranium metal billets, with a corresponding decrease in the required storage area.

In Table 2.5, comparison of the (nondiscounted) life-cycle costs for vault storage between the four chemical forms may not be valid due to the design change implemented in the Engineering Analysis Report for uranium metal storage, in which a ramp was assumed to be constructed along the side of the vault to allow easy access. In addition, utility use is higher for uranium metal storage to avoid enhanced corrosion of the uranium metal to allow for continuous operation of the HEPA filtration system.

## 2.2 COST UNCERTAINTY

Long-lived investments, such as process plants, are characterized by uncertainties regarding project life, operation and maintenance costs, and other factors that affect project economics. Since values of these variable factors are generally unknown, it is difficult to make economic evaluations with a high degree of certainty. One approach to this uncertainty problem is to use sensitivity analysis — a simple, inexpensive technique for handling uncertainties that can offer some perspective regarding the accuracy of the cost estimates.

Tables 2.6 and 2.7 present the uncertainty analysis in terms of costs and factors, respectively, as the probability of cost overruns varies. These tables give five points (10%, 25%, 50%, 75%, and 90%) on the total cost cumulative distribution. These points show the uncertainty in the cost estimates at WBS Level V for each facility type. The Cost Estimate Report indicates that the probability distribution is based on experience for similar facilities and on engineering judgment. It notes, however, that based on the data available from Yucca Mountain geological repository for radioactive waste and the Waste Isolation Pilot Plant (WIPP), there is considerable variation in unit prices for excavation and maintenance for underground facilities. The costs for these items appear high — certainly much higher than would be typical of commercial mining

operations. By using cost data available from the Yucca Mountain and WIPP projects, it is anticipated that the cost estimates for storage in a mined cavity can be expected to be bounding in terms of maximum cost.

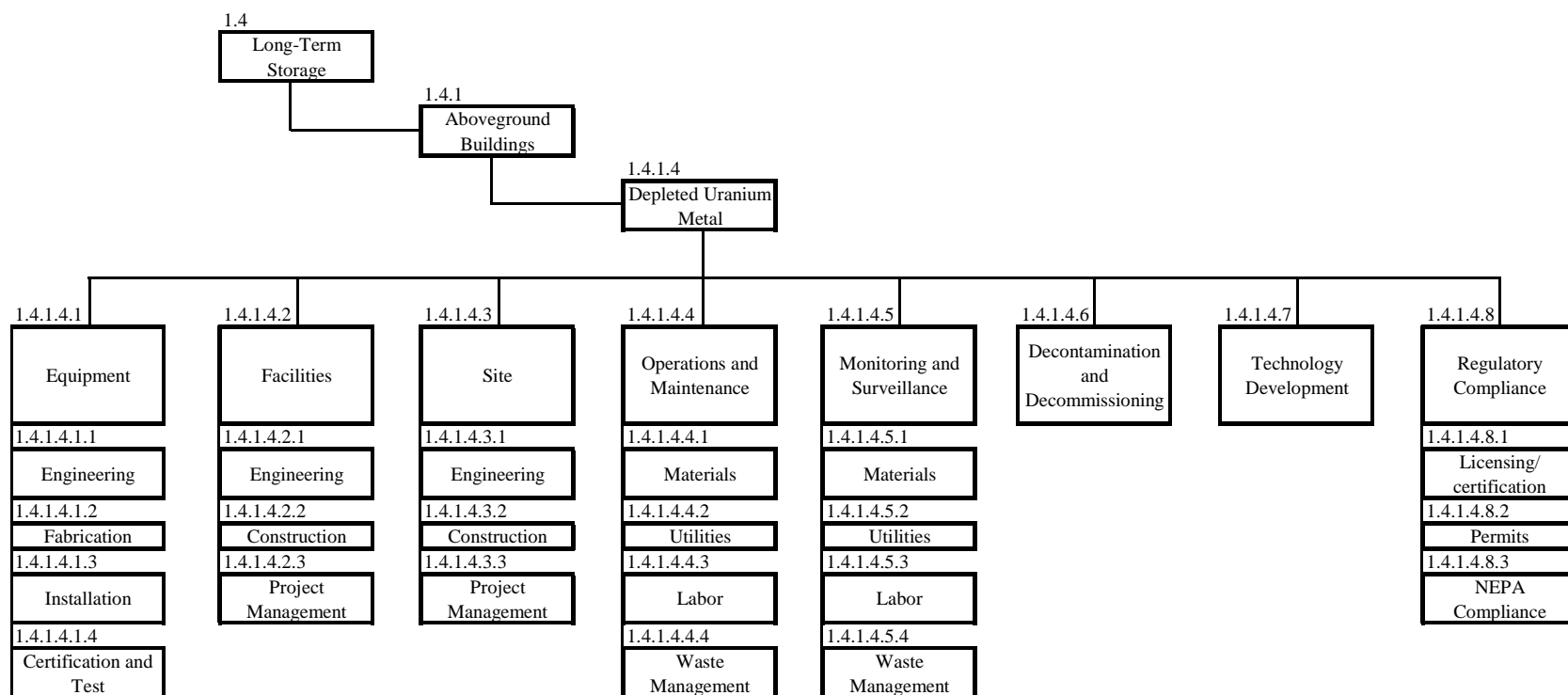
## 2.3 COST SCHEDULE

Figure 2.4 shows the project schedule. After a DOE Record of Decision (ROD), there would be a period of approximately one year for developing management plans, obtaining approvals, and determining initial budgets. Next there would be a period of approximately three years for developing and testing the form (alloy) for the depleted uranium billets and generating baseline design parameters. Parallel to this technology verification task would be a design task and a safety approval and National Environmental Policy Act (NEPA) process task. It is estimated that after four years these tasks should be far enough along that a construction application could be submitted. After two more years, the final design and final safety analysis would be completed so that construction approval would be granted.

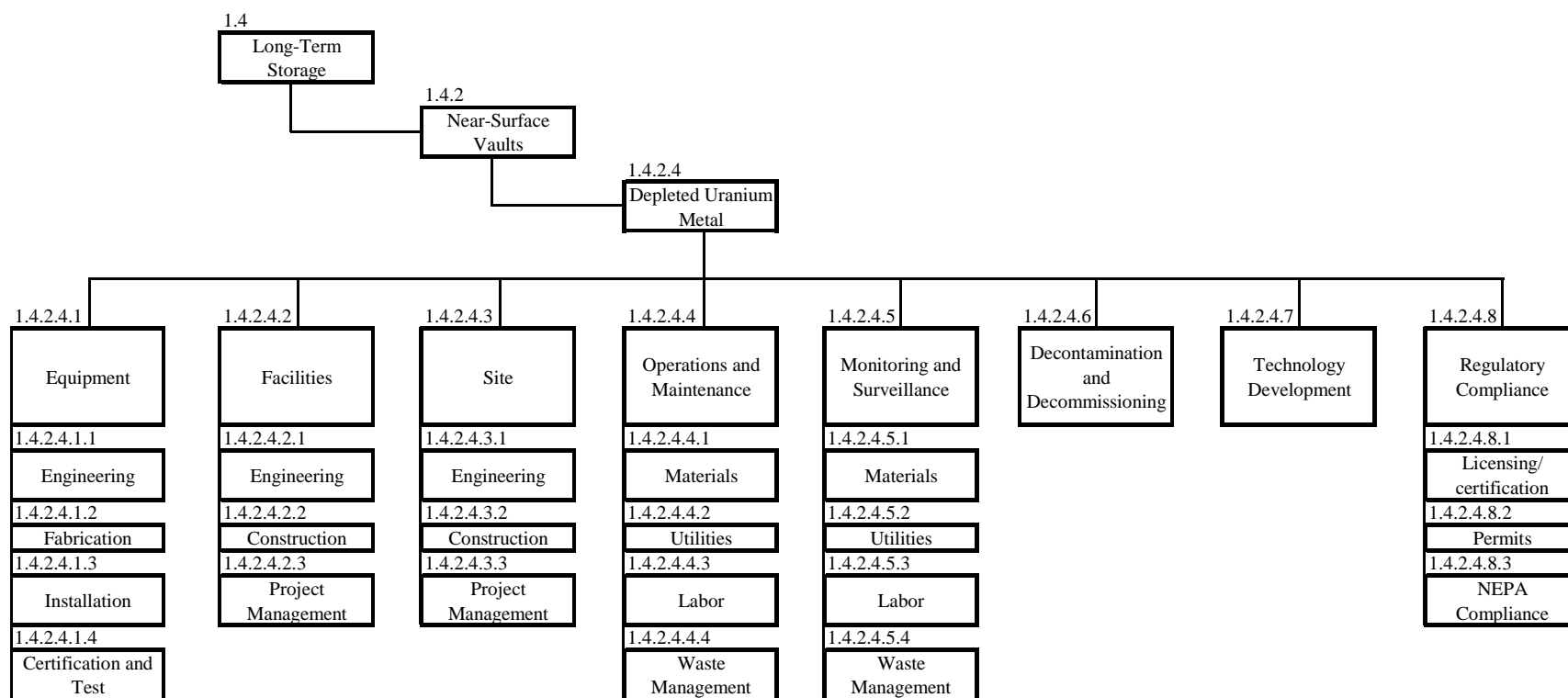
It is estimated that three years would be required to build the support buildings and the first storage enclosures, so that operation would begin after nine years from the start of the schedule. During the first 20 years of operation, boxes of depleted uranium billets would be received and placed in storage enclosures, which would be constructed as needed over this 20-year period. Then there would be a 20-year period during which no more depleted uranium would be received, and operations would be mainly surveillance and monitoring, with repackaging of billets from boxes that were found to be damaged. During the last three years of this phase, D&D would occur and, after 49 years, the life cycle of the storage facility would be completed and the site returned to its original greenfield state.

Tables 2.8 through 2.10 show the Phase I, Level V, life-cycle cost by year for building storage, vault storage, and mined-cavity storage, respectively. As expected, the majority of the costs occur during the first 20 years of construction and operations and decrease dramatically (e.g., from \$28 million per year to \$10.6 million per year, as shown in Table 2.7) during the 20 years of surveillance and monitoring.

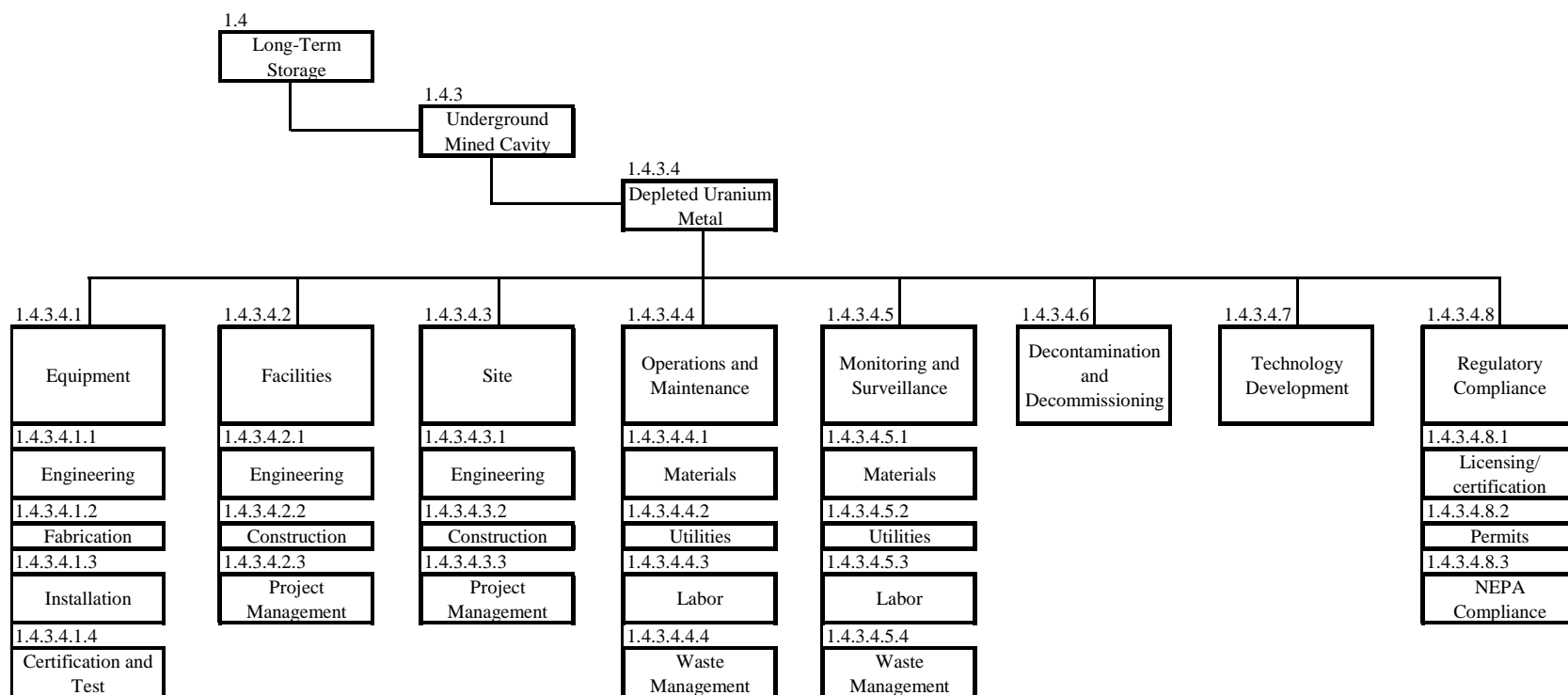
Also as expected, the costs of storage in buildings is much lower on an annual basis than that for vaults or mined cavities.



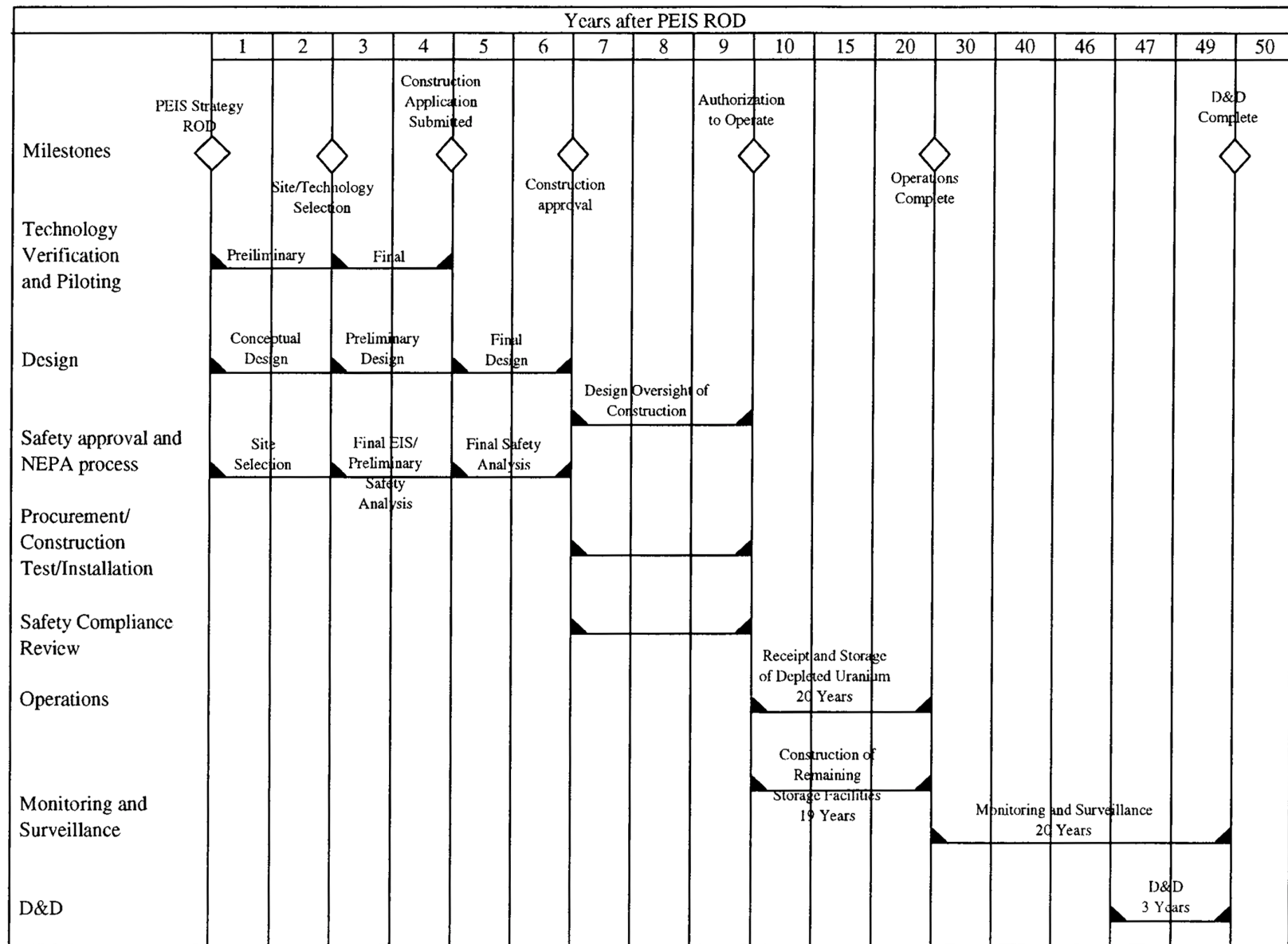
**FIGURE 2.1 Work Breakdown Structure for Long-Term Storage in Buildings**



**FIGURE 2.2 Work Breakdown Structure for Long-Term Storage in Vaults**



**FIGURE 2.3 Work Breakdown Structure for Long-Term Storage in Underground Mined Cavities**



**FIGURE 2.4 Estimated Overall Schedule for the Depleted Uranium Storage Facility**



**TABLE 2.1 Phase I, WBS Level V, Median Life-Cycle Costs:  
Building Storage of Uranium Metal**

Sec.	WBS	Category	Cost in \$ million (1996)
4.1.4.1	1.4.1.4.1	Equipment	6
4.1.4.2	1.4.1.4.2	Facilities	326
4.1.4.3	1.4.1.4.3	Site	16
4.1.4.4	1.4.1.4.4	Regulatory Compliance	excluded
		<b>Total Phase I Facility Capital Costs</b>	<b>348</b>
4.1.4.5	1.4.1.4.5	Operations and Maintenance (40.65 years)	491
4.1.4.6	1.4.1.4.6	Decontamination and Decommissioning	35
		<b>Total Phase I Costs</b>	<b>874</b>

**TABLE 2.2 Phase I, WBS Level V, Median Life-Cycle Costs: Vault  
Storage of Uranium Metal**

Sec.	WBS	Category	Cost in \$ million (1996)
4.2.1	1.4.2.4.1	Equipment	8
4.2.2	1.4.2.4.2	Facilities	468
4.2.3	1.4.2.4.3	Site	20
4.2.4	1.4.2.4.4	Regulatory Compliance	excluded
		<b>Total Phase I Facility Capital Costs</b>	<b>496</b>
4.2.5	1.4.2.4.5	Operations and Maintenance (40.65 years)	636
4.2.6	1.4.2.4.6	Decontamination and Decommissioning	50
		<b>Total Phase I Costs</b>	<b>1,182</b>

**TABLE 2.3 Phase I, WBS Level V, Median Life-Cycle Costs: Mined-Cavity Storage of Uranium Metal**

Sec.	WBS	Category	Cost in \$ million (1996)
4.3.1	1.4.3.4.1	Equipment	8
4.3.2	1.4.3.4.2	Facilities	670
4.3.3	1.4.3.4.3	Site	13
4.3.4	1.4.3.4.4	Regulatory Compliance	excluded
		<b>Total Phase I Facility Capital Costs</b>	<b>691</b>
4.3.5	1.4.3.4.5	Operations and Maintenance (40.65 years)	1,130
4.3.6	1.4.3.4.6	Decontamination and Decommissioning	69
		<b>Total Phase I Costs</b>	<b>1,890</b>

**TABLE 2.4 Net Present-Value Cost Breakdown for Long-Term Storage of Uranium Metal (\$ million)**

Cost Component	Buildings	Vaults	Mined Cavities
<b>Tech. Development</b>	0.82	1.64	3.28
<b>Equipment</b>			
Engineering	0.53	0.52	0.52
Fabrication	1.40	1.49	1.52
Installation	0.88	0.75	0.72
Certification & Test	0.07	0.07	0.08
Subtotal	2.88	2.83	2.84
<b>Facilities</b>			
Engineering	18.68	26.07	46.33
Construction	77.54	108.18	192.07
Proj. Management	6.53	9.10	16.07
Subtotal	102.75	143.35	254.47
<b>Balance of Plant</b>			
Engineering	1.61	2.01	1.41
Construction	6.48	8.05	5.61
Proj. Management	0.56	0.70	0.49
Subtotal	8.65	10.76	7.51
<b>Regulatory Compliance</b>	18.61	18.61	18.61
<b>Operations and Maintenance</b>			
Material	9.90	13.80	119.38
Utilities	17.61	20.10	12.97
Labor	63.62	83.01	71.35
Waste Management & Disposal	0.15	0.15	0.15
Subtotal	91.28	117.06	203.85
<b>D&amp;D<sup>a,b</sup></b>	0.00	0.00	0.00
<b>Total</b>	224.99	294.26	490.56

<sup>a</sup> To facilitate comparison of the above discounted costs with those presented in the Cost Analysis Report, the D&D costs were set equal to zero in this table.

<sup>b</sup> The D&D costs of the various storage options are as follows:

Building: \$0.98 million  
Vaults: \$1.49 million  
Mined cavity: \$2.35 million

**TABLE 2.5 Nondiscounted Life-Cycle Cost for Each Storage Option (\$ million)**

Type of Storage Enclosures	UF <sub>6</sub>	U <sub>3</sub> O <sub>8</sub>	UO <sub>2</sub>	U-Metal
Aboveground Buildings	782	837	531	874
Below-grade Vaults	----	873	557	1,184
Underground Mined Cavities	2,460	2,830	1,800	1,890

**TABLE 2.6 Uncertainty Analysis: Cost in \$ Million**

CER Sec. No.	WBS No.	Description	Probability of Overrun				
			90%	75%	50%	25%	10%
Aboveground Storage, Uranium Metal							
4.1.4.1	1.4.1.4.1	Equipment	5	5	6	7	7
	1.4.1.4.1.1	Engineering	1	1	1	1	1
	1.4.1.4.1.2	Fabrication	2	3	3	3	3
	1.4.1.4.1.3	Installation	1	2	2	2	2
	1.4.1.4.1.4	Certification and Test	0	0	0	0	0
4.1.4.2	1.4.1.4.2	Facilities	255	289	326	363	396
	1.4.1.4.2.1	Engineering	47	53	59	65	71
	1.4.1.4.2.2	Construction	192	218	246	274	300
4.1.4.3	1.4.1.4.2.3	Project Management	16	18	21	23	25
	1.4.1.4.3	Site	13	14	16	18	19
	1.4.1.4.3.1	Engineering	2	3	3	3	4
	1.4.1.4.3.2	Construction	10	11	12	13	14
	1.4.1.4.3.3	Project Management	1	1	1	1	1
4.1.4.4	1.4.1.4.4	Operations and Maintenance	358	421	491	561	624
	1.4.1.4.4.1	Emplacement	202	238	279	319	355
	1.4.1.4.4.1.1	Materials	21	26	32	38	43
	1.4.1.4.4.1.2	Utilities	42	47	52	57	62
	1.4.1.4.4.1.3	Labor	139	165	194	223	249
	1.4.1.4.4.1.4	Waste Management	0	0	1	1	1
	1.4.1.4.4.2	Monitoring and Surveillance	156	182	212	242	269
	1.4.1.4.4.2.1	Materials	11	14	18	21	24
	1.4.1.4.4.2.2	Utilities	41	46	52	57	62
	1.4.1.4.4.2.3	Labor	103	122	143	164	183
	1.4.1.4.4.2.4	Waste Management	0	0	0	0	0
	1.4.1.4	Total	631	729	839	948	1,047
Below-grade Storage, Uranium Metal							
4.2.4.1	1.4.2.4.1	Equipment	6	7	8	9	10
	1.4.2.4.1.1	Engineering	1	1	1	2	2
	1.4.2.4.1.2	Fabrication	3	4	4	5	5
	1.4.2.4.1.3	Installation	1	2	2	2	3
	1.4.2.4.1.4	Certification and Test	0	0	0	0	0
4.2.4.2	1.4.2.4.2	Facilities	367	414	468	521	569
	1.4.2.4.2.1	Engineering	68	76	85	94	102
	1.4.2.4.2.2	Construction	276	312	353	394	430
4.2.4.3	1.4.2.4.2.3	Project Management	23	26	30	33	36
	1.4.2.4.3	Site	16	18	20	22	24
	1.4.2.4.3.1	Engineering	3	3	4	4	4
	1.4.2.4.3.2	Construction	12	13	15	17	18
	1.4.2.4.3.3	Project Management	1	1	1	1	2
4.2.4.4	1.4.2.4.4	Operations and Maintenance	460	544	636	728	811
	1.4.2.4.4.1	Emplacement	255	302	354	406	452
	1.4.2.4.4.1.1	Materials	29	37	45	53	61
	1.4.2.4.4.1.2	Utilities	47	53	59	66	71
	1.4.2.4.4.1.3	Labor	178	212	249	286	320
	1.4.2.4.4.1.4	Waste Management	0	0	1	1	1
	1.4.2.4.4.2	Monitoring and Surveillance	205	242	282	323	359
	1.4.2.4.4.2.1	Materials	16	20	24	29	33
	1.4.2.4.4.2.2	Utilities	47	53	59	65	71
	1.4.2.4.4.2.3	Labor	142	169	199	229	256
	1.4.2.4.4.2.4	Waste Management	0	0	0	0	0
	1.4.2.4	Total	849	983	1,132	1,280	1,414

**TABLE 2.6 (Cont.)**

CER Sec. No.	WBS No.	Description	Probability of Overrun				
			90%	75%	50%	25%	10%
Underground Storage, Uranium Metal							
4.3.4.1	1.4.3.4.1	Equipment	6	7	8	9	10
	1.4.3.4.1.1	Engineering	1	1	1	2	2
	1.4.3.4.1.2	Fabrication	3	4	4	5	6
	1.4.3.4.1.3	Installation	1	2	2	2	2
	1.4.3.4.1.4	Certification and Test	0	0	0	0	0
4.3.4.2	1.4.3.4.2	Facilities	400	528	670	813	941
	1.4.3.4.2.1	Engineering	98	109	122	135	146
	1.4.3.4.2.2	Construction	269	381	506	631	743
	1.4.3.4.2.3	Project Management	33	37	42	47	52
4.3.4.3	1.4.3.4.3	Site	11	12	13	14	16
	1.4.3.4.3.1	Engineering	2	2	2	3	3
	1.4.3.4.3.2	Construction	8	9	10	11	12
	1.4.3.4.3.3	Project Management	1	1	1	1	1
4.3.4.4	1.4.3.4.4	Operations and Maintenance	678	890	1,126	1,361	1,574
	1.4.3.4.4.1	Emplacement	378	493	620	747	862
	1.4.3.4.4.1.1	Materials	185	266	355	444	525
	1.4.3.4.4.1.2	Utilities	31	34	38	42	46
	1.4.3.4.4.1.3	Labor	162	192	226	260	290
	1.4.3.4.4.1.4	Waste Management	0	0	1	1	1
	1.4.3.4.4.2	Monitoring and Surveillance	300	397	506	614	712
	1.4.3.4.4.2.1	Materials	176	253	338	423	500
	1.4.3.4.4.2.2	Utilities	30	34	38	42	45
	1.4.3.4.4.2.3	Labor	93	111	130	149	167
	1.4.3.4.4.2.4	Waste Management	0	0	0	0	0
1.4.3.4	Total	1,094	1,436	1,817	2,198	2,540	

**TABLE 2.7 Uncertainty Analysis: Factors**

CER Sec. No.	WBS No.	Description	Probability of Overrun				
			90%	75%	50%	25%	10%
<b>Aboveground Storage, Uranium Metal</b>							
4.1.4.1	1.4.1.4.1	Equipment	0.775	0.881	1.000	1.119	1.225
	1.4.1.4.1.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.1.2	Fabrication	0.808	0.899	1.000	1.101	1.192
	1.4.1.4.1.3	Installation	0.705	0.845	1.000	1.155	1.295
	1.4.1.4.1.4	Certification and Test	0.808	0.899	1.000	1.101	1.192
4.1.4.2	1.4.1.4.2	Facilities	0.784	0.886	1.000	1.114	1.216
	1.4.1.4.2.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.2.2	Construction	0.781	0.885	1.000	1.115	1.219
	1.4.1.4.2.3	Project Management	0.776	0.882	1.000	1.118	1.224
4.1.4.3	1.4.1.4.3	Site	0.801	0.895	1.000	1.105	1.199
	1.4.1.4.3.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.3.2	Construction	0.804	0.897	1.000	1.103	1.196
4.1.4.4	1.4.1.4.3.3	Project Management	0.776	0.882	1.000	1.118	1.224
	1.4.1.4.4	Operations and Maintenance	0.728	0.857	1.000	1.143	1.272
	1.4.1.4.4.1	Emplacement	0.726	0.856	1.000	1.144	1.274
	1.4.1.4.4.1.1	Materials	0.649	0.815	1.000	1.185	1.351
	1.4.1.4.4.1.2	Utilities	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.4.1.3	Labor	0.718	0.852	1.000	1.148	1.282
	1.4.1.4.4.1.4	Waste Management	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.4.2	Monitoring and Surveillance	0.732	0.859	1.000	1.141	1.268
	1.4.1.4.4.2.1	Materials	0.649	0.815	1.000	1.185	1.351
	1.4.1.4.4.2.2	Utilities	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.4.2.3	Labor	0.718	0.852	1.000	1.148	1.282
	1.4.1.4.4.2.4	Waste Management	0.800	0.895	1.000	1.105	1.200
	1.4.1.4	Total	0.752	0.869	1.000	1.131	1.248
<b>Below-grade Storage, Uranium Metal</b>							
4.2.4.1	1.4.2.4.1	Equipment	0.780	0.884	1.000	1.116	1.220
	1.4.2.4.1.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.2.4.1.2	Fabrication	0.808	0.899	1.000	1.101	1.192
	1.4.2.4.1.3	Installation	0.705	0.845	1.000	1.155	1.295
	1.4.2.4.1.4	Certification and Test	0.808	0.899	1.000	1.101	1.192
4.2.4.2	1.4.2.4.2	Facilities	0.784	0.886	1.000	1.114	1.216
	1.4.2.4.2.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.2.4.2.2	Construction	0.781	0.885	1.000	1.115	1.219
	1.4.2.4.2.3	Project Management	0.776	0.882	1.000	1.118	1.224
4.2.4.3	1.4.2.4.3	Site	0.801	0.895	1.000	1.105	1.199
	1.4.2.4.3.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.2.4.3.2	Construction	0.804	0.897	1.000	1.103	1.196
4.2.4.4	1.4.2.4.3.3	Project Management	0.776	0.882	1.000	1.118	1.224
	1.4.2.4.4	Operations and Maintenance	0.724	0.855	1.000	1.145	1.276
	1.4.2.4.4.1	Emplacement	0.721	0.853	1.000	1.147	1.279
	1.4.2.4.4.1.1	Materials	0.649	0.815	1.000	1.185	1.351
	1.4.2.4.4.1.2	Utilities	0.800	0.895	1.000	1.105	1.200
	1.4.2.4.4.1.3	Labor	0.715	0.850	1.000	1.150	1.285
	1.4.2.4.4.1.4	Waste Management	0.800	0.895	1.000	1.105	1.200
	1.4.2.4.4.2	Monitoring and Surveillance	0.727	0.857	1.000	1.143	1.273
	1.4.2.4.4.2.1	Materials	0.649	0.815	1.000	1.185	1.351
	1.4.2.4.4.2.2	Utilities	0.800	0.895	1.000	1.105	1.200
	1.4.2.4.4.2.3	Labor	0.715	0.850	1.000	1.150	1.285
	1.4.2.4.4.2.4	Waste Management	0.800	0.895	1.000	1.105	1.200
	1.4.2.4	Total	0.751	0.869	1.000	1.131	1.249

**TABLE 2.7 (Cont.)**

CER Sec. No.	WBS No.	Description	Probability of Overrun				
			90%	75%	50%	25%	10%
<b>Underground Storage, Uranium Metal</b>							
4.3.4.1	1.4.3.4.1	Equipment	0.728	0.857	1.000	1.143	1.272
	1.4.3.4.1.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.3.4.1.2	Fabrication	0.710	0.848	1.000	1.152	1.290
	1.4.3.4.1.3	Installation	0.705	0.845	1.000	1.155	1.295
	1.4.3.4.1.4	Certification and Test	0.808	0.899	1.000	1.101	1.192
4.3.4.2	1.4.3.4.2	Facilities	0.596	0.788	1.000	1.212	1.404
	1.4.3.4.2.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.3.4.2.2	Construction	0.532	0.754	1.000	1.246	1.468
	1.4.3.4.2.3	Project Management	0.776	0.882	1.000	1.118	1.224
4.3.4.3	1.4.3.4.3	Site	0.801	0.895	1.000	1.105	1.199
	1.4.3.4.3.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.3.4.3.2	Construction	0.804	0.897	1.000	1.103	1.196
	1.4.3.4.3.3	Project Management	0.776	0.882	1.000	1.118	1.224
4.3.4.4	1.4.3.4.4	Operations and Maintenance	0.602	0.791	1.000	1.209	1.398
	1.4.3.4.4.1	Emplacement	0.610	0.795	1.000	1.205	1.390
	1.4.3.4.4.1.1	Materials	0.522	0.748	1.000	1.252	1.478
	1.4.3.4.4.1.2	Utilities	0.800	0.895	1.000	1.105	1.200
	1.4.3.4.4.1.3	Labor	0.715	0.850	1.000	1.150	1.285
	1.4.3.4.4.1.4	Waste Management	0.800	0.895	1.000	1.105	1.200
	1.4.3.4.4.2	Monitoring and Surveillance	0.593	0.786	1.000	1.214	1.407
	1.4.3.4.4.2.1	Materials	0.522	0.748	1.000	1.252	1.478
	1.4.3.4.4.2.2	Utilities	0.800	0.895	1.000	1.105	1.200
	1.4.3.4.4.2.3	Labor	0.715	0.850	1.000	1.150	1.285
	1.4.3.4.4.2.4	Waste Management	0.800	0.895	1.000	1.105	1.200
	1.4.3.4	Total	0.602	0.791	1.000	1.209	1.398



**TABLE 2.8 Phase I, WBS Level V, Life-Cycle Costs by Year: Building Storage of Uranium Metal**

		Construction Costs (\$)										
		Year 1	2	3	4	5	6	7	8	9	10	Subtotal
1.4.1.4.1	Equipment									2,490,000	2,530,000	5,020,000
1.4.1.4.1.1	Engineering									457,000	465,000	922,000
1.4.1.4.1.2	Fabrication									1,220,000	1,240,000	2,460,000
1.4.1.4.1.3	Installation									752,000	767,000	1,520,000
1.4.1.4.1.4	Certification and Test									61,200	62,200	123,000
1.4.1.4.2	Facility									18,700,000	33,100,000	51,800,000
1.4.1.4.2.1	Engineering									3,400,000	6,020,000	9,420,000
1.4.1.4.2.2	Construction									14,000,000	24,900,000	38,900,000
1.4.1.4.2.3	Project Management									1,250,000	2,160,000	3,410,000
1.4.1.4.3	Site									12,100,000	4,050,000	16,200,000
1.4.1.4.3.1	Engineering									2,260,000	753,000	3,010,000
1.4.1.4.3.2	Construction									9,080,000	3,030,000	12,100,000
1.4.1.4.3.3	Project Management									788,000	263,000	1,050,000
1.4.1.4.5	O&M										6,100,000	6,100,000
1.4.1.4.5.1	Emplacement										6,100,000	6,100,000
1.4.1.4.5.1.1	Materials											
1.4.1.4.5.1.2	Utilities											
1.4.1.4.5.1.3	Labor										6,100,000	6,100,000
1.4.1.4.5.1.4	Waste Management											
1.4.1.4.5.2	Monitoring and Surveillance											
1.4.1.4.5.2.1	Materials											
1.4.1.4.5.2.2	Utilities											
1.4.1.4.5.2.3	Labor											
1.4.1.4.5.2.4	Waste Management											
1.4.1.4.6	D&D											
	Total Cost									31,300,000	43,700,000	75,000,000

**TABLE 2.8 (Cont.)**

		Emplacement Costs (\$)										Subtotal
		Year 11	12	13	14	15	16	17	18	19	20	
1.4.1.4.1	Equipment	44,900	44,900	44,900	44,900	44,900	44,900	44,900	44,900	44,900	44,900	1,370,000
1.4.1.4.1.1	Engineering	7,850	7,850	7,850	7,850	7,850	7,850	7,850	7,850	7,850	7,850	2,540,000
1.4.1.4.1.2	Fabrication	20,600	20,600	20,600	20,600	20,600	20,600	20,600	20,600	20,600	20,600	1,730,000
1.4.1.4.1.3	Installation	15,400	15,400	15,400	15,400	15,400	15,400	15,400	15,400	15,400	15,400	277,000
1.4.1.4.1.4	Certification and Test	1,030	1,030	1,030	1,030	1,030	1,030	1,030	1,030	1,030	1,030	5,030,000
1.4.1.4.2	Facility	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	196,000,000
1.4.1.4.2.1	Engineering	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	35,600,000
1.4.1.4.2.2	Construction	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	148,000,000
1.4.1.4.2.3	Project Management	905,000	905,000	905,000	905,000	905,000	905,000	905,000	905,000	905,000	905,000	12,500,000
1.4.1.4.3	Site											16,200,000
1.4.1.4.3.1	Engineering											3,010,000
1.4.1.4.3.2	Construction											12,100,000
1.4.1.4.3.3	Project Management											1,050,000
1.4.1.4.5	O&M	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	142,000,000
1.4.1.4.5.1	Emplacement	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	142,000,000
1.4.1.4.5.1.1	Materials	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	16,100,000
1.4.1.4.5.1.2	Utilities	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	26,000,000
1.4.1.4.5.1.3	Labor	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	100,000,000
1.4.1.4.5.1.4	Waste Management	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	272,000
1.4.1.4.5.2	Monitoring and Surveillance											
1.4.1.4.5.2.1	Materials											
1.4.1.4.5.2.2	Utilities											
1.4.1.4.5.2.3	Labor											
1.4.1.4.5.2.4	Waste Management											
1.4.1.4.6	D&D											
	Total Cost	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	355,000,000

**TABLE 2.8 (Cont.)**

		Emplacement Costs (\$) (Cont.)										
		Year 21	22	23	24	25	26	27	28	29	30	Subtotal
1.4.1.4.1	Equipment	44,900	44,900	44,900	44,900	44,900	44,900	44,900	44,900	44,900		1,770,000
1.4.1.4.1.1	Engineering	7,850	7,850	7,850	7,850	7,850	7,850	7,850	7,850	7,850		2,610,000
1.4.1.4.1.2	Fabrication	20,600	20,600	20,600	20,600	20,600	20,600	20,600	20,600	20,600		1,920,000
1.4.1.4.1.3	Installation	15,400	15,400	15,400	15,400	15,400	15,400	15,400	15,400	15,400		416,000
1.4.1.4.1.4	Certification and Test	1,030	1,030	1,030	1,030	1,030	1,030	1,030	1,030	1,030		5,040,000
1.4.1.4.2	Facility	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000	14,400,000		326,000,000
1.4.1.4.2.1	Engineering	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000	2,620,000		59,200,000
1.4.1.4.2.2	Construction	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000		246,000,000
1.4.1.4.2.3	Project Management	905,000	905,000	905,000	905,000	905,000	905,000	905,000	905,000	905,000		20,600,000
1.4.1.4.3	Site											16,200,000
1.4.1.4.3.1	Engineering											3,010,000
1.4.1.4.3.2	Construction											12,100,000
1.4.1.4.3.3	Project Management											1,050,000
1.4.1.4.5	O&M	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	278,000,000
1.4.1.4.5.1	Emplacement	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	13,600,000	278,000,000
1.4.1.4.5.1.1	Materials	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	1,610,000	32,200,000
1.4.1.4.5.1.2	Utilities	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	2,600,000	52,000,000
1.4.1.4.5.1.3	Labor	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	9,390,000	194,000,000
1.4.1.4.5.1.4	Waste Management	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	544,000
1.4.1.4.5.2	Monitoring and Surveillance											
1.4.1.4.5.2.1	Materials											
1.4.1.4.5.2.2	Utilities											
1.4.1.4.5.2.3	Labor											
1.4.1.4.5.2.4	Waste Management											
1.4.1.4.6	D&D											
	Total Cost	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	28,000,000	13,600,000	621,000,000

**TABLE 2.8 (Cont.)**

		Monitoring and Surveillance Costs (\$)										
		Year 31	32	33	34	35	36	37	38	39	40	Subtotal
1.4.1.4.1	Equipment											1,770,000
1.4.1.4.1.1	Engineering											2,610,000
1.4.1.4.1.2	Fabrication											1,920,000
1.4.1.4.1.3	Installation											416,000
1.4.1.4.1.4	Certification and Test											5,040,000
1.4.1.4.2	Facility											326,000,000
1.4.1.4.2.1	Engineering											59,200,000
1.4.1.4.2.2	Construction											246,000,000
1.4.1.4.2.3	Project Management											20,600,000
1.4.1.4.3	Site											16,200,000
1.4.1.4.3.1	Engineering											3,010,000
1.4.1.4.3.2	Construction											12,100,000
1.4.1.4.3.3	Project Management											1,050,000
1.4.1.4.5	O&M	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	384,000,000
1.4.1.4.5.1	Emplacement											278,000,000
1.4.1.4.5.1.1	Materials											32,200,000
1.4.1.4.5.1.2	Utilities											52,000,000
1.4.1.4.5.1.3	Labor											194,000,000
1.4.1.4.5.1.4	Waste Management											544,000
1.4.1.4.5.2	Monitoring and Surveillance	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	106,000,000
1.4.1.4.5.2.1	Materials	885,000	885,000	885,000	885,000	885,000	885,000	885,000	885,000	885,000	885,000	8,850,000
1.4.1.4.5.2.2	Utilities	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	25,900,000
1.4.1.4.5.2.3	Labor	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	71,500,000
1.4.1.4.5.2.4	Waste Management	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	12,400
1.4.1.4.6	D&D											
	Total Cost	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	727,000,000

**TABLE 2.8 (Cont.)**

		Monitoring and Surveillance Costs (\$) (Cont.)										
		Year 41	42	43	44	45	46	47	48	49	50	Subtotal
1.4.1.4.1	Equipment											1,770,000
1.4.1.4.1.1	Engineering											2,610,000
1.4.1.4.1.2	Fabrication											1,920,000
1.4.1.4.1.3	Installation											416,000
1.4.1.4.1.4	Certification and Test											5,040,000
1.4.1.4.2	Facility											326,000,000
1.4.1.4.2.1	Engineering											59,200,000
1.4.1.4.2.2	Construction											246,000,000
1.4.1.4.2.3	Project Management											20,600,000
1.4.1.4.3	Site											16,200,000
1.4.1.4.3.1	Engineering											3,010,000
1.4.1.4.3.2	Construction											12,100,000
1.4.1.4.3.3	Project Management											1,050,000
1.4.1.4.5	O&M	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	490,000,000
1.4.1.4.5.1	Emplacement											278,000,000
1.4.1.4.5.1.1	Materials											32,200,000
1.4.1.4.5.1.2	Utilities											52,000,000
1.4.1.4.5.1.3	Labor											194,000,000
1.4.1.4.5.1.4	Waste Management											544,000
1.4.1.4.5.2	Monitoring and Surveillance	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	212,000,000
1.4.1.4.5.2.1	Materials	885,000	885,000	885,000	885,000	885,000	885,000	885,000	885,000	885,000	885,000	17,700,000
1.4.1.4.5.2.2	Utilities	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	2,590,000	51,800,000
1.4.1.4.5.2.3	Labor	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	143,000,000
1.4.1.4.5.2.4	Waste Management	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	24,800
1.4.1.4.6	D&D										34,400,000	34,400,000
	Total Cost	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	10,600,000	45,000,000	867,000,000

**TABLE 2.9 Phase I, WBS Level V, Life-Cycle Costs by Year: Vault Storage of Uranium Metal**

		Construction Costs (\$)										
		Year 1	2	3	4	5	6	7	8	9	10	Subtotal
1.4.2.4.1	Equipment									1,060,000	1,360,000	2,420,000
1.4.2.4.1.1	Engineering									195,000	249,000	444,000
1.4.2.4.1.2	Fabrication									540,000	700,000	1,240,000
1.4.2.4.1.3	Installation									300,000	376,000	676,000
1.4.2.4.1.4	Certification and Test									27,000	35,000	62,000
1.4.2.4.2	Facility									17,400,000	39,100,000	56,500,000
1.4.2.4.2.1	Engineering									3,250,000	7,180,000	10,400,000
1.4.2.4.2.2	Construction									13,000,000	29,400,000	42,400,000
1.4.2.4.2.3	Project Management									1,150,000	2,520,000	3,670,000
1.4.2.4.3	Site									15,100,000	5,020,000	20,100,000
1.4.2.4.3.1	Engineering									2,810,000	938,000	3,750,000
1.4.2.4.3.2	Construction									11,300,000	3,750,000	15,100,000
1.4.2.4.3.3	Project Management									983,000	328,000	1,310,000
1.4.2.4.5	O&M										7,870,000	7,870,000
1.4.2.4.5.1	Emplacement										7,870,000	7,870,000
1.4.2.4.5.1.1	Materials											
1.4.2.4.5.1.2	Utilities											
1.4.2.4.5.1.3	Labor										7,870,000	7,870,000
1.4.2.4.5.1.4	Waste Management											
1.4.2.4.5.2	Monitoring and Surveillance											
1.4.2.4.5.2.1	Materials											
1.4.2.4.5.2.2	Utilities											
1.4.2.4.5.2.3	Labor											
1.4.2.4.5.2.4	Waste Management											
1.4.2.4.6	D&D											
	Total Cost									33,600,000	53,400,000	87,000,000

**TABLE 2.9 (Cont.)**

		Emplacement Costs (\$)										
		Year 11	12	13	14	15	16	17	18	19	20	Subtotal
1.4.2.4.1	Equipment	298,000	298,000	298,000	298,000	298,000	298,000	298,000	298,000	298,000	298,000	5,400,000
1.4.2.4.1.1	Engineering	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	984,000
1.4.2.4.1.2	Fabrication	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	2,840,000
1.4.2.4.1.3	Installation	75,500	75,500	75,500	75,500	75,500	75,500	75,500	75,500	75,500	75,500	1,430,000
1.4.2.4.1.4	Certification and Test	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	142,000
1.4.2.4.2	Facility	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	274,000,000
1.4.2.4.2.1	Engineering	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	49,700,000
1.4.2.4.2.2	Construction	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	206,000,000
1.4.2.4.2.3	Project Management	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	17,400,000
1.4.2.4.3	Site											20,100,000
1.4.2.4.3.1	Engineering											3,750,000
1.4.2.4.3.2	Construction											15,100,000
1.4.2.4.3.3	Project Management											1,310,000
1.4.2.4.5	O&M	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	181,000,000
1.4.2.4.5.1	Emplacement	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	181,000,000
1.4.2.4.5.1.1	Materials	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	22,500,000
1.4.2.4.5.1.2	Utilities	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	29,700,000
1.4.2.4.5.1.3	Labor	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	129,000,000
1.4.2.4.5.1.4	Waste Management	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	272,000
1.4.2.4.5.2	Monitoring and Surveillance											
1.4.2.4.5.2.1	Materials											
1.4.2.4.5.2.2	Utilities											
1.4.2.4.5.2.3	Labor											
1.4.2.4.5.2.4	Waste Management											
1.4.2.4.6	D&D											
	Total Cost	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	480,000,000

**TABLE 2.9 (Cont.)**

		Emplacement Costs (\$) (Cont.)										Subtotal
		Year 21	22	23	24	25	26	27	28	29	30	
1.4.2.4.1	Equipment	298,000	298,000	298,000	298,000	298,000	298,000	298,000	298,000	298,000		8,080,000
1.4.2.4.1.1	Engineering	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000		1,470,000
1.4.2.4.1.2	Fabrication	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000		4,280,000
1.4.2.4.1.3	Installation	75,500	75,500	75,500	75,500	75,500	75,500	75,500	75,500	75,500		2,110,000
1.4.2.4.1.4	Certification and Test	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000		214,000
1.4.2.4.2	Facility	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000		469,000,000
1.4.2.4.2.1	Engineering	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000		85,100,000
1.4.2.4.2.2	Construction	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000		354,000,000
1.4.2.4.2.3	Project Management	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000		29,700,000
1.4.2.4.3	Site											20,100,000
1.4.2.4.3.1	Engineering											3,750,000
1.4.2.4.3.2	Construction											15,100,000
1.4.2.4.3.3	Project Management											1,310,000
1.4.2.4.5	O&M	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	354,000,000
1.4.2.4.5.1	Emplacement	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	17,300,000	354,000,000
1.4.2.4.5.1.1	Materials	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	2,250,000	45,000,000
1.4.2.4.5.1.2	Utilities	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	2,970,000	59,400,000
1.4.2.4.5.1.3	Labor	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	12,100,000	250,000,000
1.4.2.4.5.1.4	Waste Management	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	544,000
1.4.2.4.5.2	Monitoring and Surveillance											
1.4.2.4.5.2.1	Materials											
1.4.2.4.5.2.2	Utilities											
1.4.2.4.5.2.3	Labor											
1.4.2.4.5.2.4	Waste Management											
1.4.2.4.6	D&D											
	Total Cost	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	39,300,000	17,300,000	851,000,000



**TABLE 2.9 (Cont.)**

		Monitoring and Surveillance Costs (\$)										Subtotal
		Year 31	32	33	34	35	36	37	38	39	40	
1.4.2.4.1	Equipment											8,080,000
1.4.2.4.1.1	Engineering											1,470,000
1.4.2.4.1.2	Fabrication											4,280,000
1.4.2.4.1.3	Installation											2,110,000
1.4.2.4.1.4	Certification and Test											214,000
1.4.2.4.2	Facility											469,000,000
1.4.2.4.2.1	Engineering											85,100,000
1.4.2.4.2.2	Construction											354,000,000
1.4.2.4.2.3	Project Management											29,700,000
1.4.2.4.3	Site											20,100,000
1.4.2.4.3.1	Engineering											3,750,000
1.4.2.4.3.2	Construction											15,100,000
1.4.2.4.3.3	Project Management											1,310,000
1.4.2.4.5	O&M	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	495,000,000
1.4.2.4.5.1	Emplacement											354,000,000
1.4.2.4.5.1.1	Materials											45,000,000
1.4.2.4.5.1.2	Utilities											59,400,000
1.4.2.4.5.1.3	Labor											250,000,000
1.4.2.4.5.1.4	Waste Management											544,000
1.4.2.4.5.2	Monitoring and Surveillance	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	141,000,000
1.4.2.4.5.2.1	Materials	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	12,100,000
1.4.2.4.5.2.2	Utilities	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	29,500,000
1.4.2.4.5.2.3	Labor	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	99,500,000
1.4.2.4.5.2.4	Waste Management	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	12,400
1.4.2.4.6	D&D											
	Total Cost	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	992,000,000

**TABLE 2.9 (Cont.)**

		Monitoring and Surveillance Costs (\$) (Cont.)										Subtotal
		Year 41	42	43	44	45	46	47	48	49	50	
1.4.2.4.1	Equipment											8,080,000
1.4.2.4.1.1	Engineering											1,470,000
1.4.2.4.1.2	Fabrication											4,280,000
1.4.2.4.1.3	Installation											2,110,000
1.4.2.4.1.4	Certification and Test											214,000
1.4.2.4.2	Facility											469,000,000
1.4.2.4.2.1	Engineering											85,100,000
1.4.2.4.2.2	Construction											354,000,000
1.4.2.4.2.3	Project Management											29,700,000
1.4.2.4.3	Site											20,100,000
1.4.2.4.3.1	Engineering											3,750,000
1.4.2.4.3.2	Construction											15,100,000
1.4.2.4.3.3	Project Management											1,310,000
1.4.2.4.5	O&M	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	636,000,000
1.4.2.4.5.1	Emplacement											354,000,000
1.4.2.4.5.1.1	Materials											45,000,000
1.4.2.4.5.1.2	Utilities											59,400,000
1.4.2.4.5.1.3	Labor											250,000,000
1.4.2.4.5.1.4	Waste Management											544,000
1.4.2.4.5.2	Monitoring and Surveillance	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	282,000,000
1.4.2.4.5.2.1	Materials	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	1,210,000	24,200,000
1.4.2.4.5.2.2	Utilities	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	2,950,000	59,000,000
1.4.2.4.5.2.3	Labor	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	9,950,000	199,000,000
1.4.2.4.5.2.4	Waste Management	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	24,800
1.4.2.4.6	D&D										49,700,000	49,700,000
	Total Cost	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	14,100,000	63,800,000	1,180,000,000

**TABLE 2.10 Phase I, WBS Level V, Life-Cycle Costs by Year: Mined-Cavity Storage of Uranium Metal**

		Construction Costs (\$)										
		Year 1	2	3	4	5	6	7	8	9	10	Subtotal
1.4.3.4.1	Equipment								768,000	768,000	1,040,000	2,576,000
1.4.3.4.1.1	Engineering								140,000	140,000	190,000	470,000
1.4.3.4.1.2	Fabrication								357,000	357,000	520,000	1,234,000
1.4.3.4.1.3	Installation								253,000	253,000	307,000	813,000
1.4.3.4.1.4	Certification and Test								17,700	17,700	25,900	61,300
1.4.3.4.2	Facility								79,200,000	79,200,000	101,000,000	259,400,000
1.4.3.4.2.1	Engineering								14,500,000	14,500,000	18,400,000	47,400,000
1.4.3.4.2.2	Construction								59,700,000	59,700,000	76,100,000	195,500,000
1.4.3.4.2.3	Project Management								5,000,000	5,000,000	6,370,000	16,370,000
1.4.3.4.3	Site								9,840,000	3,280,000		13,120,000
1.4.3.4.3.1	Engineering								1,850,000	615,000		2,465,000
1.4.3.4.3.2	Construction								7,350,000	2,450,000		9,800,000
1.4.3.4.3.3	Project Management								642,000	214,000		856,000
1.4.3.4.5	O&M										7,090,000	7,090,000
1.4.3.4.5.1	Emplacement										7,090,000	7,090,000
1.4.3.4.5.1.1	Materials											
1.4.3.4.5.1.2	Utilities											
1.4.3.4.5.1.3	Labor										7,090,000	7,090,000
1.4.3.4.5.1.4	Waste Management											
1.4.3.4.5.2	Monitoring and Surveillance											
1.4.3.4.5.2.1	Materials											
1.4.3.4.5.2.2	Utilities											
1.4.3.4.5.2.3	Labor											
1.4.3.4.5.2.4	Waste Management											
1.4.3.4.6	D&D											
	Total Cost								89,800,000	83,200,000	109,000,000	282,000,000

**TABLE 2.10 (Cont.)**

		Emplacement Costs (\$)										
		Year 11	12	13	14	15	16	17	18	19	20	Subtotal
1.4.3.4.1	Equipment	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	5,330,000
1.4.3.4.1.1	Engineering	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	970,000
1.4.3.4.1.2	Fabrication	163,000	163,000	163,000	163,000	163,000	163,000	163,000	163,000	163,000	163,000	2,860,000
1.4.3.4.1.3	Installation	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	1,350,000
1.4.3.4.1.4	Certification and Test	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	143,000
1.4.3.4.2	Facility	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	476,000,000
1.4.3.4.2.1	Engineering	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	86,700,000
1.4.3.4.2.2	Construction	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	360,000,000
1.4.3.4.2.3	Project Management	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	30,100,000
1.4.3.4.3	Site											13,100,000
1.4.3.4.3.1	Engineering											2,470,000
1.4.3.4.3.2	Construction											9,800,000
1.4.3.4.3.3	Project Management											856,000
1.4.3.4.5	O&M	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	313,000,000
1.4.3.4.5.1	Emplacement	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	313,000,000
1.4.3.4.5.1.1	Materials	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	178,000,000
1.4.3.4.5.1.2	Utilities	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	19,200,000
1.4.3.4.5.1.3	Labor	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	116,000,000
1.4.3.4.5.1.4	Waste Management	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	272,000
1.4.3.4.5.2	Monitoring and Surveillance											
1.4.3.4.5.2.1	Materials											
1.4.3.4.5.2.2	Utilities											
1.4.3.4.5.2.3	Labor											
1.4.3.4.5.2.4	Waste Management											
1.4.3.4.6	D&D											
	Total Cost	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	808,000,000

**TABLE 2.10 (Cont.)**

		Emplacement Costs (\$) (Cont.)										Subtotal
		Year 21	22	23	24	25	26	27	28	29	30	
1.4.3.4.1	Equipment	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000	275,000		7,810,000
1.4.3.4.1.1	Engineering	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000		1,420,000
1.4.3.4.1.2	Fabrication	163,000	163,000	163,000	163,000	163,000	163,000	163,000	163,000	163,000		4,330,000
1.4.3.4.1.3	Installation	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000		1,840,000
1.4.3.4.1.4	Certification and Test	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200	8,200		217,000
1.4.3.4.2	Facility	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000	21,700,000		671,000,000
1.4.3.4.2.1	Engineering	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000	3,930,000		122,000,000
1.4.3.4.2.2	Construction	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000	16,400,000		508,000,000
1.4.3.4.2.3	Project Management	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000	1,370,000		42,400,000
1.4.3.4.3	Site											13,100,000
1.4.3.4.3.1	Engineering											2,470,000
1.4.3.4.3.2	Construction											9,800,000
1.4.3.4.3.3	Project Management											856,000
1.4.3.4.5	O&M	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	619,000,000
1.4.3.4.5.1	Emplacement	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	30,600,000	619,000,000
1.4.3.4.5.1.1	Materials	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	17,800,000	356,000,000
1.4.3.4.5.1.2	Utilities	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	1,920,000	38,400,000
1.4.3.4.5.1.3	Labor	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	10,900,000	225,000,000
1.4.3.4.5.1.4	Waste Management	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	27,200	544,000
1.4.3.4.5.2	Monitoring and Surveillance											
1.4.3.4.5.2.1	Materials											
1.4.3.4.5.2.2	Utilities											
1.4.3.4.5.2.3	Labor											
1.4.3.4.5.2.4	Waste Management											
1.4.3.4.6	D&D											
	Total Cost	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	52,600,000	30,600,000	1,310,000,000

**TABLE 2.10 (Cont.)**

		Monitoring and Surveillance Costs (\$)										Subtotal
		Year 31	32	33	34	35	36	37	38	39	40	
1.4.3.4.1	Equipment											7,810,000
1.4.3.4.1.1	Engineering											1,420,000
1.4.3.4.1.2	Fabrication											4,330,000
1.4.3.4.1.3	Installation											1,840,000
1.4.3.4.1.4	Certification and Test											217,000
1.4.3.4.2	Facility											671,000,000
1.4.3.4.2.1	Engineering											122,000,000
1.4.3.4.2.2	Construction											508,000,000
1.4.3.4.2.3	Project Management											42,400,000
1.4.3.4.3	Site											13,100,000
1.4.3.4.3.1	Engineering											2,470,000
1.4.3.4.3.2	Construction											9,800,000
1.4.3.4.3.3	Project Management											856,000
1.4.3.4.5	O&M	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	872,000,000
1.4.3.4.5.1	Emplacement											619,000,000
1.4.3.4.5.1.1	Materials											356,000,000
1.4.3.4.5.1.2	Utilities											38,400,000
1.4.3.4.5.1.3	Labor											225,000,000
1.4.3.4.5.1.4	Waste Management											544,000
1.4.3.4.5.2	Monitoring and Surveillance	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	253,000,000
1.4.3.4.5.2.1	Materials	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	169,000,000
1.4.3.4.5.2.2	Utilities	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	18,900,000
1.4.3.4.5.2.3	Labor	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	65,000,000
1.4.3.4.5.2.4	Waste Management	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	12,400
1.4.3.4.6	D&D											
	Total Cost	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	1,560,000,000

**TABLE 2.10 (Cont.)**

		Monitoring and Surveillance Costs (\$) (Cont.)										Subtotal
		Year 41	42	43	44	45	46	47	48	49	50	
1.4.3.4.1	Equipment											7,810,000
1.4.3.4.1.1	Engineering											1,420,000
1.4.3.4.1.2	Fabrication											4,330,000
1.4.3.4.1.3	Installation											1,840,000
1.4.3.4.1.4	Certification and Test											217,000
1.4.3.4.2	Facility											671,000,000
1.4.3.4.2.1	Engineering											122,000,000
1.4.3.4.2.2	Construction											508,000,000
1.4.3.4.2.3	Project Management											42,400,000
1.4.3.4.3	Site											13,100,000
1.4.3.4.3.1	Engineering											2,470,000
1.4.3.4.3.2	Construction											9,800,000
1.4.3.4.3.3	Project Management											856,000
1.4.3.4.5	O&M	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	1,130,000,000
1.4.3.4.5.1	Emplacement											619,000,000
1.4.3.4.5.1.1	Materials											356,000,000
1.4.3.4.5.1.2	Utilities											38,400,000
1.4.3.4.5.1.3	Labor											225,000,000
1.4.3.4.5.1.4	Waste Management											544,000
1.4.3.4.5.2	Monitoring and Surveillance	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	506,000,000
1.4.3.4.5.2.1	Materials	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	16,900,000	338,000,000
1.4.3.4.5.2.2	Utilities	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	1,890,000	37,800,000
1.4.3.4.5.2.3	Labor	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	6,500,000	130,000,000
1.4.3.4.5.2.4	Waste Management	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	1,240	24,800
1.4.3.4.6	D&D										69,200,000	69,200,000
	Total Cost	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	25,300,000	94,500,000	1,880,000,000

### **3 ASSUMPTIONS AND EXCLUSIONS**

#### **3.1 ASSUMPTIONS**

Several assumptions have been used in the cost analysis, as stated in the Cost Estimate Report. One major assumption in the costing of facilities is that they require a minimal level of radiation control. The only exception is the repackaging area of the receiving warehouse and repackaging building.

Another assumption is that storage buildings and vaults require heating and cooling, but that mined cavities require only ventilation because they are underground and tend to have more nearly uniform temperatures than buildings and vaults.

The space required for storage of depleted uranium metal in the three types of storage enclosures is the major determinant of facility cost. Buildings other than the storage enclosures account for a small fraction of overall costs. Therefore, space within these buildings (receiving warehouse and repackaging building, administration building, and workshop) was not optimized for the uranium metal chemical form. Rather, the general layouts used for the other three chemical forms were adopted for uranium metal.

#### **3.2 EXCLUSIONS**

The following major items have been excluded from the cost estimates:

- Cost of land;
- Research and development and technical development costs;
- Regulatory compliance costs (NEPA, licensing, and permitting);
- DOE oversight costs;
- Revenues;
- Transportation costs; and
- Escalation beyond the first quarter of FY 1996.

On the basis of the Cost Analysis Report, the above costs can be expected to be minor with respect to the costs shown in this report for the construction and operating phases.

#### **3.3 ADDED ITEMS**

It should be noted that the cost of several items are included here that were not considered in the Cost Estimate Report. Some of these items are expressly mentioned in the Engineering



Analysis Report — Uranium Metal. Other items would be present to comply with safety requirements, including emergency generators to ensure continued operation of ventilation equipment in the event that electrical service to the site is lost and radiation monitoring stations to measure worker exposure.

The cost of the following items has been added to equipment costs:

- An emergency diesel generator to provide backup electricity to the receiving warehouse and repackaging building in the event that power from the grid is lost;
- An emergency diesel generator in each storage building or each vault to provide backup electricity in the event that power from the grid is lost;
- Several (eight) emergency generators in the mined cavity to provide backup electricity in the event that power from the grid is lost;
- An uninterruptible power supply in the receiving warehouse and repackaging building to provide short duration power to equipment in the event that power from the grid is lost;
- Grounding of aboveground structures;
- Radiation monitoring stations for the storage enclosures;
- Communication equipment (speaker systems, raceway, and cabling); and
- Instrumentation (field instruments, panels, valves, and bulk items).

In addition, the sprinkler system under facilities has been upgraded (which results in an increase in unit cost from \$3.50/ft<sup>2</sup> to \$4.50/ft<sup>2</sup> of floor area to be protected). As discussed in the Engineering Analysis Report — Uranium Metal, uranium metal and water reactions can release hydrogen. The upgraded sprinkler system would be of the pre-action type to reduce the likelihood of inadvertent activation of the sprinkler system. In this type of system, a supplemental heat responsive system must be activated before water will flow through the sprinkler piping system. Also, the sprinkler system was upgraded to hazard-grade components.

## 4 COST ESTIMATES

Cost estimates have been developed for each WBS of Level VI or lower. The estimating approach and supporting data used to develop estimates are discussed below. Unless otherwise noted, the estimating approach and unit costs used in the Cost Estimate Report have been adopted for uranium metal.

The costs in this report were developed by using activity-based cost (ABC) estimating. ABC estimating is a method for preparing cost estimates by which work is broken down into discrete, quantifiable activities. The cost of each activity is then estimated in terms of requirements for labor and materials on a per unit basis. The cost for each activity is equal to the labor hours required, multiplied by the labor costs plus material, and subcontracting costs. This can be expressed as:

$$C = HD + M + S$$

where:

C = Estimated activity cost,

H = Labor hours required to perform this activity once,

D = Dollars per labor hour (fully burdened),

M = Material costs (including equipment) to perform the activity once (fully burdened), and

S = Subcontracting cost to perform the activity once (fully burdened).

Depleted uranium metal in the form of billets will be stored in wood boxes that are 2 ft long by 2 ft wide by 1 ft high. When loaded with 19 billets, each box will weigh 1,475 lb. These boxes will be placed on pallets, four boxes per pallet, and will be stacked 4 pallets high in storage in each type of enclosure. Thus, there will be 16 boxes of depleted uranium per stack. Except when moving a damaged box, boxes will be moved four at a time on a pallet. Because the weight of a pallet of uranium metal boxes and the U<sub>3</sub>O<sub>8</sub> drums is similar, the capacity of the equipment for handling the boxes and pallets for uranium metal used in the Engineering Analysis Report — Uranium Metal is similar to the capacity of the equipment for handling pallets and drums of U<sub>3</sub>O<sub>8</sub>. Therefore, the unit costs for handling equipment (cranes, forklifts, and straddle carriers) in the Cost Estimate Report for U<sub>3</sub>O<sub>8</sub> will be used for uranium metal.

Boxes of depleted uranium would be received at the receiving warehouse, inspected, and either relocated to a storage enclosure or, if the box is damaged, sent to the repackaging area of the receiving warehouse and repackaging building to be repackaged.

#### **4.1 ABOVEGROUND BUILDINGS (WBS 1.4.1.4)**

The storage buildings would be steel-walled and roofed buildings on concrete pads. They would be 271 m long by 50 m wide by 5 m high. Eight buildings would be needed to store all the depleted uranium generated by DOE prior to July 1993.

##### **4.1.1 Equipment (WBS 1.4.1.4.1)**

The equipment costs for the aboveground facility would be determined primarily by the cost of equipment for handling pallets of uranium metal boxes. These are 5-ton davit cranes and 5-ton bridge cranes, 5-ton straddle carriers, and 5-ton forklifts. The Cost Estimate Report states that costs for forklifts and davit canes were obtained from vendor quotes; costs of bridge cranes were obtained from standard estimating manuals.

The direct costs for equipment include not only the equipment, but also the initial spare parts, which are needed to ensure process operation in the event of a failure of a major piece of installed equipment. The cost of initial spare parts is taken to be 10% of the material cost of the equipment. In addition to materials, direct costs include labor, subcontractors, and tax on materials (6%).

There are also indirect costs. Indirect costs are distributables (general conditions), overhead, and profit. Distributables include support to direct construction for temporary construction facilities, construction equipment, construction support, field offices expenses, and craft supervision. Construction facilities include on-site offices, warehouses, shops, change rooms, construction roads, and construction parking lots. Distributable field costs for materials are taken as 28% of the direct labor costs; distributable field costs for labor are taken as 75% of the direct labor costs. The contractor's overhead and profit is taken as 5% of the total direct and distributable field material costs and 15% of the total direct and distributable field labor costs. Another indirect cost is the contractor's bond, taken as 1% of the total contractor contract value. An additional contractor cost is associated with construction management and is taken as 10% of the contractor's cost. Other costs associated with architect/engineering (A/E) and program management are taken as 6% of all other costs.

Equipment costs are spread among four WBS groups. These groups are A/E (WBS 1.4.1.4.1.1), fabrication (WBS 1.4.1.4.1.2), installation (WBS 1.1.1.4.1.3), and certification and testing (WBS 1.4.1.4.1.4).

The A/E costs are included at 25% of the total field costs. These costs cover Title I, II, and III design, engineering, and field verification. The Cost Analysis Report describes activities included in Titles I through III. Title I involves the preliminary design and is usually the first line-item-funded design effort for a facility. It includes detailed drawings, bills of material, and craft labor requirements. A Title I cost estimate is also produced. An A/E firm is often used for this level of design effort. The design at this stage is site specific. Title II design produces the final pre-construction drawings, bills of material, and other specifications. The same A/E firm that developed the Title I design is often used for Title II. Title III is engineering that takes place primarily during construction and involves verification that the Title II final design is being implemented. Contingencies for equipment A/E are taken as 30% of the A/E costs.

Costs for fabrication include costs for shop or field fabrication of process equipment, piping, or instrumentation and are estimated as a percentage of the total estimated cost of equipment, including markups. Contingencies for equipment fabrication are taken as 30% of the fabrication costs.

Costs for installation include costs associated with field installation of process equipment. They are estimated as a percentage of the total cost of equipment, including markups. Contingencies for equipment installation are taken as 35% of the installation costs.

Costs for certification and testing (WBS 1.4.4.1.4) are estimated at 5% of fabrication cost. Contingencies for equipment certification and testing are taken as 30% of the equipment certification and testing costs.

Summary costs for equipment at a long-term storage facility with aboveground storage of depleted uranium metal in buildings are given in Table 4.1.

#### **4.1.2 Facilities (WBS 1.4.1.4.2)**

The cost of constructing the storage buildings and the receiving warehouse and repackaging building fall within the Facilities WBS. The costs of all these buildings are estimated in the same way by using unit costs and areas for walls and roofing, volumes for concrete and excavation, and scaled allowances for electrical systems, HVAC, and piping.

The facilities cost for storage buildings is the largest individual cost for the long-term storage facility. These buildings are of standard construction. They sit on a concrete pad and have steel walls and roofs. Piping is limited to water distribution for fire control, and electric wiring is primarily for lighting, HVAC, and HEPA filtration.

The receiving warehouse and repackaging building has construction similar to storage buildings — steel walls and a roof built on a concrete pad. Compared to a storage building, this

building requires support for bridge cranes, and air locks and steel walls define the repackaging area where uranium billets are repackaged from damaged to fresh wooden boxes. Additional wiring and plumbing are required to handle bridge cranes and other internal equipment and for safety showers and toilet facilities.

The Facilities WBS has three Level VI components: construction (WBS 1.4.1.4.2.2), engineering (WBS 1.4.1.4.2.1), and project management (WBS 1.4.1.4.2.3). Construction costs include the costs of construction materials and costs associated with field installation of all bulk construction materials and support equipment. According to the Cost Estimate Report, manual labor rates were developed on the basis of a hypothetical greenfield site in Kenosha, Wisconsin. Consequently, labor costs are based on Davis-Bacon manual labor rates for Kenosha, Wisconsin, worker compensation insurance rates for Wisconsin, and a standard 40-hour workweek with an allowance for casual overtime at 1% of each total labor wage rate.

Direct facilities construction costs occur for the storage buildings and the receiving warehouse and repackaging building. As for the equipment, these costs are broken up into materials, labor, subcontractors, and tax costs. Also, as for equipment, the indirect costs are distributable field costs, contractor profit and overhead, contractor's bond, and construction management. Contingencies for facilities construction are taken as 30% of the construction costs. The A/E and program management functions are additional costs.

The A/E costs that include conceptual, Title I, II, and III design, engineering, and field verification are taken as 25% of total field costs. Contingencies for facilities A/E are taken as 25% of the A/E costs.

Project management costs include all required construction management and owner management. It is assumed that DOE will hire an A/E construction manager to interact with the design A/E, equipment vendors, and construction field labor. Project management costs are taken as 6% of all engineering (A/E) and construction costs and have a contingency of 45%.

Summary costs for facilities at a long-term storage facility with aboveground storage of depleted uranium metal in buildings are given in Table 4.2.

#### **4.1.3 Site (WBS 1.4.1.4.3)**

The Site WBS includes the costs of site improvements and utilities. It also includes construction of the administration building and the workshop. Site improvements include roads, parking areas, fencing, landscaping, and railroad spurs. Utility costs include the costs of domestic, service, and fire water systems; a stack; yard piping and electrical systems; and site material handling and transport vehicles.

The Site WBS has three Level VI components: construction (WBS 1.4.1.4.2.2), engineering (WBS 1.4.1.4.2.1), and project management (WBS 1.4.1.4.2.3). Construction costs include the costs of material and labor associated with the construction of the administration building and the workshop. It also includes the cost of materials and labor associated with site improvements and utilities. There are four direct site cost line items: site improvement and utilities, mobile yard equipment, the administration building, and the workshop. The other construction costs are as before. The contingencies for site construction are taken as 25% of the site construction costs.

The A/E costs that include Title I, II, and III design, engineering, and field verification are taken as 25% of total field costs. The contingencies in A/E costs are taken as 25% of the A/E costs. Project management costs include all required construction management and owner management. It is assumed that DOE will hire an A/E construction manager to interact with the design A/E, equipment vendors, and construction field labor. Project management costs are taken as 6% of all engineering (A/E) and construction costs. Contingencies in project management costs are taken as 45% of project management costs.

Summary site costs at a long-term storage facility with aboveground storage of depleted uranium metal in buildings are given in Table 4.3.

#### **4.1.4 Regulatory Compliance (WBS 1.4.1.4.4)**

The Cost Estimate Report does not include cost estimates for permits, licensing, and environmental documentation. To be consistent with the Cost Estimate Report, costs associated with regulatory compliance are not estimated in this report.

#### **4.1.5 Operations and Maintenance (WBS 1.4.1.4.5)**

The O&M cost estimates include total annual costs for wages of operating personnel, utilities, consumables, operations materials, maintenance expenditures, and waste management. Operations differ significantly during the emplacement phase and the monitoring and surveillance phase. During the emplacement phase, depleted uranium is received at the storage facility and placed in storage enclosures. During the monitoring and surveillance phase, all depleted uranium has been stored at the facility and, except for the rare repackaging of a damaged box, operations are directed toward monitoring and surveillance. Therefore, O&M activities during the emplacement phase have a different Level VI WBS designation (WBS 1.4.1.4.5.1) than during the monitoring and surveillance phase (WBS 1.4.1.4.5.2).

There are four Level VII WBS designations: materials (WBS 1.4.1.4.5.1.1 and WBS 1.4.1.4.5.2.1), utilities (WBS 1.4.1.4.5.1.2 and WBS 1.4.1.4.5.2.2), labor (WBS 1.4.1.4.5.1.3 and WBS 1.4.1.4.5.2.3), and waste management (WBS 1.4.1.4.5.1.4 and WBS 1.4.1.4.5.2.4). The

contingencies for these components are taken as 30% for material, 35% for utilities, 25% for labor, and 35% for waste management.

The Engineering Analysis Report — Uranium Metal served as the basis for estimates of usage of materials, utilities (electricity, natural gas, and water), generation of wastes, and person-hours of effort. Wages for non-manual operating personnel are based on national averages that were current during the first quarter of FY 1996 (wages for manual operating personnel were based on Davis-Bacon guidelines). Because the mechanical equipment would be used full-time during the emplacement phase, it is assumed that such mechanical equipment would be replaced every five years during the emplacement phase, but would not be replaced during the monitoring and surveillance phase. These replacement costs appear as material costs.

Three kinds of waste would be disposed of: non-hazardous solid waste, non-hazardous liquid (sanitary) waste, and low-level radioactive waste (LLW). Sanitary waste would be transferred to an on-site sanitary waste system for treatment. Non-hazardous solid waste disposal costs are assumed to be \$2/ft<sup>3</sup>, and LLW disposal costs are assumed to be \$100/ft<sup>3</sup>.

Summary operations and maintenance costs are presented in Table 4.4 for the emplacement phase and in Table 4.5 for monitoring and surveillance phase.

#### **4.1.6 Decontamination and Decommissioning (WBS 1.4.1.4.6)**

As stated in the Cost Estimate Report, the cost of D&D is taken as 10% of the total facility costs, per recent DOE guidelines. This percentage may be realistic given the low potential for radioactive contamination of the various facilities during operations.

## **4.2 BELOW-GRADE VAULTS (WBS 1.4.2.4)**

The storage vaults are partly subsurface reinforced concrete structures with 0.3-m thick walls. They are 5 m in height, of which 4.6 m are below the surface. These vaults are 79 m long by 40 m wide. Forty vaults would be needed to store all the depleted uranium generated by DOE prior to July 1993.

In most respects, the methodology used to estimate costs for a storage facility with below-grade vaults is identical with that used for a storage facility with aboveground buildings. Quantities may differ, but unit costs and unit efforts are generally the same. One area where differences in unit costs occur is the emergency generators. There would be fewer, larger storage buildings than storage vaults (8 versus 40). Therefore, the generators in vaults would be smaller and less expensive than the generators for aboveground buildings. In this report, cost estimates were based on 350-kW generators in storage buildings and 75-kW generators in vaults.

Summary cost estimates are found in Table 4.6 for equipment costs (WBS 1.4.2.4.1); in Table 4.7 for facility costs (WBS 1.4.2.4.2); in Table 4.8 for site costs (WBS 1.4.2.4.3); in Table 4.9 for O&M costs during the emplacement phase (WBS 1.4.2.4.4.1); and in Table 4.10 for O&M costs during the monitoring and surveillance phase (WBS 1.4.2.4.4.2).

### **4.3 UNDERGROUND MINED CAVITIES (WBS 1.4.3.4)**

In the underground storage option, depleted uranium metal would be stored in drifts that would be 12.1 m wide, 100 m long, and 5 m high. These drifts would be placed parallel in a rectangular array and connected with aisleways. A ventilation shaft (four total) would be at each corner of the array. There would also be two larger shafts for transport of boxes of depleted uranium metal and rock spoils and for transport of staff. Ninety-two drifts would be needed to store all the depleted uranium generated by DOE prior to July 1993.

In most respects, the methodology used to estimate costs for a storage facility with underground mined cavities is identical with that used for a storage facility with aboveground buildings or below-grade drifts. Quantities may differ, but unit costs and unit efforts are generally the same. However, there are different unit costs for emergency generators. For the other types of storage, there is one generator per storage enclosure. However, the mined-cavity option, in a sense, has only one cavity comprising an array of storage drifts and aisleways, rather than multiple enclosures. For this option, cost estimates were based on eight 1,000-kW generators.

Summary cost estimates are found in Table 4.11 for equipment costs (WBS 1.4.3.4.1); in Table 4.12 for facility costs (WBS 1.4.3.4.2); in Table 4.13 for site costs (WBS 1.4.3.4.3); in Table 4.14 for O&M costs during the emplacement phase (WBS 1.4.3.4.4.1); and in Table 4.15 for O&M costs during the monitoring and surveillance phase (WBS 1.4.3.4.4.2).



**TABLE 4.1 Equipment Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
									(%)	(\$)	
<b>4.1.4.1</b>	<b>1.4.1.4.1</b>	<b>Equipment</b>		<b>1,882,473</b>	<b>114,397</b>	<b>362,000</b>	<b>112,948</b>	<b>2,470,000</b>			
		Initial Spares	10% of equipment	188,247			<b>11,295</b>	<b>200,000</b>			
		<b>Total Direct Costs</b>		<b>2,070,720</b>	<b>114,397</b>	<b>362,000</b>	<b>124,243</b>	<b>2,670,000</b>			
		Distributable Field Costs	28% of DL for mat'l	32,031			1,922	34,000			
			75% of DL \$		85,798			85,800			
		Contractor's Overhead	5% of materials and subcntrct	103,536		18,100	6,212	128,000			
		and Profit	15% of DL \$		30,029			30,000			
		<b>Subtotal Contractor's Costs</b>		<b>2,206,288</b>	<b>230,225</b>	<b>380,100</b>	<b>132,377</b>	<b>2,950,000</b>			
		Contractor's Bond	1% of total contractor's cost					29,500			
		<b>Total Contractor's Field Cost</b>						<b>2,980,000</b>			
		Construction Management	10% of contractor's field cost					298,000			
		<b>Total Field Costs</b>						<b>3,280,000</b>			
		A/E Costs	25% of total field costs					820,000			
		<b>Subtotal</b>						<b>4,100,000</b>			
		Program Management	6% of subtotal costs					246,000			
		<b>Total</b>						<b>4,350,000</b>			
	<b>1.4.1.4.1</b>	<b>Equipment: Spread by CER Sec. No. (WBS)</b>									
	1.4.1.4.1.1	Engineering						820,000	30	246,000	1,070,000
	1.4.1.4.1.2	Fabrication						2,190,000	30	657,000	2,850,000
	1.4.1.4.1.3	Installation						1,340,000	35	469,000	1,810,000
	1.4.1.4.1.4	Certification and Test						110,000	30	33,000	143,000
<b>4.1.4.1</b>	<b>1.4.1.4.1</b>	<b>Total</b>						<b>4,460,000</b>		<b>1,410,000</b>	<b>5,870,000</b>

TABLE 4.2 Facility Summary Costs for Building Storage of Uranium Metal

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Unit	Hours	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
4.1.4.2	1.4.1.4.2	<b>Facilities</b>											
		Storage Buildings	1,166,922	sf	973,592	46,190,531	31,927,459	23,738,634	2,771,432	105,000,000			
		Rec Ware & Repackage	67,012	sf	169,097	5,064,201	5,384,343	1,234,447	303,852	12,000,000			
		<b>Total Direct Costs</b>				<b>51,254,732</b>	<b>37,311,802</b>	<b>24,973,080</b>	<b>3,075,284</b>	<b>117,000,000</b>			
		Distributable Field Costs	28% of DL for mat'l			10,447,305			626,838	11,100,000			
			75% of DL \$				27,983,851			28,000,000			
		Contractor's Overhead	5% of materials and subcntrct			2,562,737		1,248,654	153,764	3,970,000			
		and Profit	15% of DL \$				9,794,348			9,790,000			
		<b>Subtotal Contractor's Costs</b>				<b>64,264,773</b>	<b>75,090,002</b>	<b>26,221,735</b>	<b>3,855,886</b>	<b>170,000,000</b>			
		Contractor's Bond	1% of total contractor's cost							1,700,000			
		<b>Total Contractor's Field Cost</b>								<b>172,000,000</b>			
		Construction Management	10% of contractor's field cost							17,200,000			
		<b>Total Field Costs</b>								<b>189,000,000</b>			
		A/E Costs	25% of total field costs							47,300,000			
		<b>Subtotal</b>								<b>236,000,000</b>			
		Program Management	6% of subtotal costs							14,200,000			
		<b>Total</b>								<b>250,000,000</b>			
		<b>Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.1.4.2.1	Engineering								47,300,000	25	11,800,000	59,100,000
	1.4.1.4.2.2	Construction								189,000,000	30	56,700,000	246,000,000
	1.4.1.4.2.3	Project Management								14,200,000	45	6,390,000	20,600,000
4.1.4.2	1.4.1.4.2	<b>Total</b>								<b>251,000,000</b>		<b>74,900,000</b>	<b>326,000,000</b>

**TABLE 4.3 Site Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Unit	Hours	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
4.1.4.3	1.4.1.4.3	<b>Site</b>											
		<b>Direct Costs</b>											
		Site Improvements and Utilities				1,514,117	1,241,241	565,136	90,847	3,410,000			
		<b>Equipment</b>											
		Yard Mobile Equipment				340,000			20,400	360,000			
		<b>Support Buildings</b>											
		Administration Building	7,266	sf	15,508	624,603	470,025	1,324	37,476	1,130,000			
		Workshop	6,728	sf	7,336	706,772	252,039	1,226	42,406	1,000,000			
		<b>Total Direct Costs</b>				<b>3,185,492</b>	<b>1,963,305</b>	<b>567,687</b>	<b>191,129</b>	<b>5,900,000</b>			
		Distributable Field Costs	28% of DL for mat'l			549,725			32,984	583,000			
			75% of DL \$				1,472,479			1,470,000			
		Contractor's Overhead	5% of materials and subctrct			159,275		28,384	9,556	197,000			
		and Profit	15% of DL \$				515,368			515,000			
		<b>Subtotal Contractor's Costs</b>				<b>3,894,492</b>	<b>3,951,151</b>	<b>596,071</b>	<b>233,669</b>	<b>8,670,000</b>			
		Contractor's Bond	1% of total contractor's cost							86,700			
		<b>Total Contractor's Field Cost</b>								<b>8,760,000</b>			
		Construction Management	10% of contractor's field cost							876,000			
		<b>Total Field Costs</b>								<b>9,640,000</b>			
		A/E Costs	25% of total field costs							2,410,000			
		<b>Subtotal</b>								<b>12,100,000</b>			
		Program Management	6% of subtotal costs							726,000			
		<b>Total</b>								<b>12,800,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.1.4.3.1	Engineering								2,410,000	25	603,000	3,010,000
	1.4.1.4.3.2	Construction								9,664,000	25	2,420,000	12,100,000
	1.4.1.4.3.3	Project Management								726,000	45	327,000	1,050,000
4.1.4.3	1.4.1.4.3	<b>Total</b>								<b>12,800,000</b>		<b>3,350,000</b>	<b>16,200,000</b>

**TABLE 4.4 Emplacement Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
<b>4.1.4.5</b>	<b>1.4.1.4.5.1</b>	<b>Emplacement Direct Costs</b>							
	1.4.1.4.5.1.1	Materials	24,700,000			24,700,000			
	1.4.1.4.5.1.2	Utilities	38,500,000			38,500,000			
	1.4.1.4.5.1.3	Labor		134,000,000		134,000,000			
		Start-up Labor		4,350,000		4,350,000			
		<b>Direct Labor</b>		<b>138,000,000</b>		<b>138,000,000</b>			
		Off-site Overhead Labor		16,600,000		16,600,000			
		<b>Total Labor</b>		<b>155,000,000</b>		<b>155,000,000</b>			
	1.4.1.4.5.1.4	Waste Management			403,000	403,000			
		<b>Total</b>				<b>219,000,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>							
	1.4.1.4.5.1.1	Materials				24,700,000	30	7,410,000	32,100,000
	1.4.1.4.5.1.2	Utilities				38,500,000	35	13,500,000	52,000,000
	1.4.1.4.5.1.3	Labor				155,000,000	25	38,800,000	194,000,000
	1.4.1.4.5.1.4	Waste Management				403,000	35	141,000	544,000
<b>4.1.4.5</b>	<b>1.4.1.4.5.1</b>	<b>Total</b>				<b>219,000,000</b>		<b>59,900,000</b>	<b>279,000,000</b>

**TABLE 4.5 Monitoring and Surveillance Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
4.1.4.5	1.4.1.4.5.2	Monitoring and Surveillance							
		Direct Costs							
	1.4.1.4.5.2.1	Materials	13,600,000			13,600,000			
	1.4.1.4.5.2.2	Utilities	38,300,000			38,300,000			
	1.4.1.4.5.2.3	Labor		102,000,000		102,000,000			
		Off-site Overhead Labor		12,200,000		12,200,000			
	1.4.1.4.5.2.4	Waste Management			18,400	18,400			
		Total				166,000,000			
		Process Facilities	Spread by CER Sec. No. (WBS)						
	1.4.1.4.5.2.1	Materials				13,600,000	30	4,080,000	17,700,000
	1.4.1.4.5.2.2	Utilities				38,300,000	35	13,400,000	51,700,000
	1.4.1.4.5.2.3	Labor				114,000,000	25	28,500,000	143,000,000
	1.4.1.4.5.2.4	Waste Management				18,400	35	6,440	24,800
4.1.4.5	1.4.1.4.5.2	Total				166,000,000		46,000,000	212,000,000

**TABLE 4.6 Equipment Summary Costs for Vault Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
									(%)	(\$)	
<b>4.2.4.1</b>	<b>1.4.2.4.1</b>	<b>Equipment</b>		<b>2,819,017</b>	<b>244,288</b>	<b>42,000</b>	<b>169,141</b>	<b>3,270,000</b>			
		Initial Spares	10% of equipment	281,902			<b>16,914</b>	<b>299,000</b>			
		<b>Total Direct Costs</b>		<b>3,100,919</b>	<b>244,288</b>	<b>42,000</b>	<b>186,055</b>	<b>3,570,000</b>			
		Distributable Field Costs	28% of DL for mat'l	68,401			4,104	72,500			
			75% of DL \$		183,216			183,000			
		Contractor's Overhead	5% of materials and subctrct	155,046		2,100	9,303	166,000			
		and Profit	15% of DL \$		64,126			64,100			
		<b>Subtotal Contractor's Costs</b>		<b>3,324,365</b>	<b>491,630</b>	<b>44,100</b>	<b>199,462</b>	<b>4,060,000</b>			
		Contractor's Bond	1% of total contractor's cost					40,600			
		<b>Total Contractor's Field Cost</b>						<b>4,100,000</b>			
		Construction Management	10% of contractor's field cost					410,000			
		<b>Total Field Costs</b>						<b>4,510,000</b>			
		A/E Costs	25% of total field costs					1,130,000			
		<b>Subtotal</b>						<b>5,640,000</b>			
		Program Management	6% of subtotal costs					338,000			
		<b>Total</b>						<b>5,980,000</b>			
	<b>1.4.2.4.1</b>	<b>Equipment: Spread by CER Sec. No. (WBS)</b>									
	1.4.2.4.1.1	Engineering						1,130,000	30	339,000	1,470,000
	1.4.2.4.1.2	Fabrication						3,290,000	30	987,000	4,280,000
	1.4.2.4.1.3	Installation						1,560,000	35	546,000	2,110,000
	1.4.2.4.1.4	Certification and Test						164,500	30	49,400	214,000
<b>4.2.4.1</b>	<b>1.4.2.4.1</b>	<b>Total</b>						<b>6,140,000</b>		<b>1,920,000</b>	<b>8,070,000</b>

**TABLE 4.7 Facility Summary Costs for Vault Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Unit	Man- hours	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
<b>4.2.4.2</b>	<b>1.4.2.4.2</b>	<b>Facilities</b>											
		Vaults	1,360,691	sf	1,791,291	66,346,347	56,782,047	20,124,621	3,980,781	147,000,000			
		Rec Ware & Repackage	67,012	sf	169,103	5,211,470	5,384,584	1,234,447	312,688	12,100,000			
		<b>Total Direct Costs</b>				<b>71,557,817</b>	<b>62,166,631</b>	<b>21,359,068</b>	<b>4,293,469</b>	<b>159,000,000</b>			
		Distributable Field Costs	28% of DL for mat'l			17,406,657			1,044,399	18,500,000			
			75% of DL \$				46,624,973			46,600,000			
		Contractor's Overhead	5% of materials and subcntrct			3,577,891		1,067,953	214,673	4,860,000			
		and Profit	15% of DL \$				16,318,741			16,300,000			
		<b>Subtotal Contractor's Costs</b>				<b>92,542,365</b>	<b>125,110,345</b>	<b>22,427,021</b>	<b>5,552,542</b>	<b>245,000,000</b>			
		Contractor's Bond	1% of total contractor's cost							2,450,000			
		<b>Total Contractor's Field Cost</b>								<b>247,000,000</b>			
		Construction Management	10% of contractor's field cost							24,700,000			
		<b>Total Field Costs</b>								<b>272,000,000</b>			
		A/E Costs	25% of total field costs							68,000,000			
		<b>Subtotal</b>								<b>340,000,000</b>			
		Program Management	6% of subtotal costs							20,400,000			
		<b>Total</b>								<b>360,000,000</b>			
	<b>1.4.2.4.2</b>	<b>Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.2.4.2.1	Engineering								68,000,000	25	17,000,000	85,000,000
	1.4.2.4.2.2	Construction								271,600,000	30	81,500,000	353,000,000
	1.4.2.4.2.3	Project Management								20,400,000	45	9,180,000	29,600,000
<b>4.2.4.2</b>	<b>1.4.2.4.2</b>	<b>Total</b>								<b>360,000,000</b>		<b>108,000,000</b>	<b>468,000,000</b>

**TABLE 4.8 Site Summary Costs for Vault Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Unit	Hours	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
<b>4.2.4.3</b>	<b>1.4.2.4.3</b>	<b>Site Direct Costs</b>											
		Site Improvements and Utilities				1,712,149	1,478,260	1,486,306	102,729	4,780,000			
		<b>Equipment</b>											
		Yard Mobile Equipment				740,000			44,400	784,000			
		<b>Support Buildings</b>											
		Administration Building	7,266	sf	15,508	624,603	470,025	1,324	37,476	1,130,000			
		Workshop	6,728	sf	7,336	706,772	252,039	1,226	42,406	1,000,000			
		<b>Total Direct Costs</b>				<b>3,783,524</b>	<b>2,200,324</b>	<b>1,488,856</b>	<b>227,011</b>	<b>7,690,000</b>			
		Distributable Field Costs	28% of DL for mat'l			616,091			36,965	653,000			
			75% of DL \$				1,650,243			1,650,000			
		Contractor's Overhead	5% of materials and subcntrct			189,176		74,443	11,351	275,000			
		and Profit	15% of DL \$				577,585			578,000			
		<b>Subtotal Contractor's Costs</b>				<b>4,588,791</b>	<b>4,428,152</b>	<b>1,563,299</b>	<b>275,327</b>	<b>10,800,000</b>			
		Contractor's Bond	1% of total contractor's cost							108,000			
		<b>Total Contractor's Field Cost</b>								<b>10,900,000</b>			
		Construction Management	10% of contractor's field cost							1,090,000			
		<b>Total Field Costs</b>								<b>12,000,000</b>			
		A/E Costs	25% of total field costs							3,000,000			
		<b>Subtotal</b>								<b>15,000,000</b>			
		Program Management	6% of subtotal costs							900,000			
		<b>Total</b>								<b>15,900,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.2.4.3.1	Engineering								3,000,000	25	750,000	3,750,000
	1.4.2.4.3.2	Construction								12,000,000	25	3,000,000	15,000,000
	1.4.2.4.3.3	Project Management								900,000	45	405,000	1,310,000
<b>4.2.4.3</b>	<b>1.4.2.4.3</b>	<b>Total</b>								<b>15,900,000</b>		<b>4,160,000</b>	<b>20,100,000</b>



**TABLE 4.9 Emplacement Summary Costs for Vault Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
<b>4.2.4.5</b>	<b>1.4.2.4.5.1</b>	<b>Emplacement</b>							
		<b>Direct Costs</b>							
	1.4.2.4.5.1.1	Materials	34,500,000			34,500,000			
	1.4.2.4.5.1.2	Utilities	43,900,000			43,900,000			
	1.4.2.4.5.1.3	Labor		171,800,000		172,000,000			
		Start-up Labor		5,583,500		5,580,000			
		<b>Total Direct Labor</b>		<b>177,383,500</b>		<b>177,000,000</b>			
		Off-site Overhead Labor		21,286,020		21,300,000			
		<b>Total Labor</b>		<b>198,669,520</b>		<b>199,000,000</b>			
	1.4.2.4.5.1.4	Waste Management			403,000	403,000			
		<b>Total</b>				<b>278,000,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>							
	1.4.2.4.5.1.1	Materials				34,500,000	30	10,400,000	44,900,000
	1.4.2.4.5.1.2	Utilities				43,900,000	35	15,400,000	59,300,000
	1.4.2.4.5.1.3	Labor				199,000,000	25	49,800,000	249,000,000
	1.4.2.4.5.1.4	Waste Management				403,000	35	141,000	544,000
<b>4.2.4.5</b>	<b>1.4.2.4.5.1</b>	<b>Total</b>				<b>278,000,000</b>		<b>75,700,000</b>	<b>354,000,000</b>

**TABLE 4.10 Monitoring and Surveillance Summary Costs for Vault Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
4.2.4.5	1.4.2.4.5.2	Monitoring and Surveillance							
		Direct Costs							
	1.4.2.4.5.2.1	Materials	18,600,000			18,600,000			
	1.4.2.4.5.2.2	Utilities	43,700,000			43,700,000			
	1.4.2.4.5.2.3	Labor		142,000,000		142,000,000			
		Off-site Overhead Labor		17,000,000		17,000,000			
	1.4.2.4.5.2.4	Waste Management			18,400	18,400			
		Total				221,000,000			
		Process Facilities Spread by CER Sec. No. (WBS)							
	1.4.2.4.5.2.1	Materials				18,600,000	30	5,580,000	24,200,000
	1.4.2.4.5.2.2	Utilities				43,700,000	35	15,300,000	59,000,000
	1.4.2.4.5.2.3	Labor				159,000,000	25	39,800,000	199,000,000
	1.4.2.4.5.2.4	Waste Management				18,400	35	6,440	24,800
4.2.4.5	1.4.2.4.5.2	Total				221,000,000		60,700,000	282,000,000

**TABLE 4.11 Equipment Summary Costs for Mined-Cavity Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
									(%)	(%)	(%)
4.3.4.1	1.4.3.4.1	<b>Equipment</b>		<b>2,859,697</b>	<b>#####</b>	<b>42,000</b>	<b>171,582</b>	<b>3,190,000</b>			
		Initial Spares	10% of equipment	285,970			<b>17,158</b>	<b>303,000</b>			
		<b>Total Direct Costs</b>		<b>3,145,667</b>	<b>#####</b>	<b>42,000</b>	<b>188,740</b>	<b>3,490,000</b>			
		Distributable Field Costs	28% of DL for mat'l	34,052			2,043	36,100			
			75% of DL \$		91,210			91,200			
		Contractor's and Profit	Overhead5% of materials and subcntrct	251,653		3,360	15,099	270,000			
			15% of DL \$		31,924			31,900			
		<b>Subtotal Contractor's Costs</b>		<b>3,431,372</b>	<b>#####</b>	<b>45,360</b>	<b>205,882</b>	<b>3,920,000</b>			
		Contractor's Bond	1% of total contractor's cost					39,200			
		<b>Total Contractor's Field Cost</b>						<b>3,960,000</b>			
		Construction Management	10% of contractor's field cost					396,000			
		<b>Total Field Costs</b>						<b>4,360,000</b>			
		A/E Costs	25% of total field costs					1,090,000			
		<b>Subtotal</b>						<b>5,450,000</b>			
		Program Management	6% of subtotal costs					327,000			
		<b>Total</b>						<b>5,780,000</b>			
	<b>1.4.3.4.1</b>	<b>Equipment: Spread by CER Sec. No. (WBS)</b>									
	1.4.3.4.1.1	Engineering						1,090,000	30	327,000	1,420,000
	1.4.3.4.1.2	Fabrication						3,330,000	30	999,000	4,330,000
	1.4.3.4.1.3	Installation						1,360,000	35	476,000	1,840,000
	1.4.3.4.1.4	Certification and Test						167,000	30	50,100	217,000
<b>4.3.4.1</b>	<b>1.4.3.4.1</b>	<b>Total</b>						<b>5,950,000</b>		<b>1,850,000</b>	<b>7,810,000</b>

**TABLE 4.12 Facility Summary Costs for Mined-Cavity Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Unit	Hours	Materials (\$)	Labor (\$)	S?C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
<b>4.3.4.2</b>	<b>1.4.3.4.2</b>	<b>Facilities</b>											
		Drifts	1,704,465	sf	863,373	28,939,872	26,981,804	223,069,594	1,736,392	281,000,000			
		Rec Ware & Repackage	67,012	sf	169,103	5,841,914	5,384,584	1,234,447	350,515	12,800,000			
		<b>Total Direct Costs</b>				<b>34,781,787</b>	<b>32,366,388</b>	<b>224,304,041</b>	<b>2,086,907</b>	<b>294,000,000</b>			
		Distributable Field Costs	28% of DL for mat'l			9,062,589			543,755	9,610,000			
			75% of DL \$				24,274,791			24,300,000			
		Contractor's Overhead and Profit	5% of materials and subcntrct			1,739,089		11,215,202	104,345	13,100,000			
			15% of DL \$				8,496,177			8,500,000			
		<b>Subtotal Contractor's Costs</b>				<b>45,583,465</b>	<b>65,137,356</b>	<b>235,519,243</b>	<b>2,735,008</b>	<b>350,000,000</b>			
		Contractor's Bond	1% of total contractor's cost							3,500,000			
		<b>Total Contractor's Field Cost</b>								<b>354,000,000</b>			
		Construction Management	10% of contractor's field cost							35,400,000			
		<b>Total Field Costs</b>								<b>389,000,000</b>			
		A/E Costs	25% of total field costs							97,300,000			
		<b>Subtotal</b>								<b>486,000,000</b>			
		Program Management	6% of subtotal costs							29,200,000			
		<b>Total</b>								<b>515,000,000</b>			
		<b>Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.3.4.2.1	Engineering								97,300,000	25	24,300,000	122,000,000
	1.4.3.4.2.2	Construction								388,500,000	30	117,000,000	506,000,000
	1.4.3.4.2.3	Project Management								29,200,000	45	13,100,000	42,300,000
<b>4.3.4.2</b>	<b>1.4.3.4.2</b>	<b>Total</b>								<b>515,000,000</b>		<b>154,000,000</b>	<b>670,000,000</b>

**TABLE 4.13 Site Summary Costs for Mined-Cavity Storage of Uranium Metal**

CER Sec, No.	WBS	Facilities/Cost Items	Quantity	Unit	Hours	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6\$ (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
<b>4.3.4.3</b>	<b>1.4.3.4.3</b>	<b>Site</b>											
		<b>Direct Costs</b>											
		Site Improvements and Utilities				1,034,770	832,037	453,010	62,086	2,380,000			
		<b>Equipment</b>											
		Yard Mobile Equipment				340,000			20,400	360,000			
		<b>Support Buildings</b>											
		Administration Building	7,266	sf	15,508	624,603	470,025	1,324	37,476	1,130,000			
		Workshop	6,728	sf	7,336	706,772	252,039	1,226	42,406	1,000,000			
		<b>Total Direct Costs</b>				<b>2,706,145</b>	<b>1,554,101</b>	<b>455,560</b>	<b>162,369</b>	<b>4,870,000</b>			
		Distributable Field Costs	28% of DL for mat'l			435,148			26,109	461,000			
			75% of DL \$				1,165,576			1,170,000			
		Contractor's Overhead	5% of materials and subcntrct			135,307		22,778	8,118	166,000			
		and Profit	15% of DL \$				407,952			408,000			
		<b>Subtotal Contractor's Costs</b>				<b>3,276,601</b>	<b>3,127,629</b>	<b>478,338</b>	<b>196,596</b>	<b>7,080,000</b>			
		Contractor's Bond	1% of total contractor's cost							70,800			
		<b>Total Contractor's Field Cost</b>								<b>7,150,000</b>			
		Construction Management	10% of contractor's field cost							715,000			
		<b>Total Field Costs</b>								<b>7,870,000</b>			
		A/E Costs	25% of total field costs							1,970,000			
		<b>Subtotal</b>								<b>9,840,000</b>			
		Program Management	6% of subtotal costs							590,000			
		<b>Total</b>								<b>10,400,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.3.4.3.1	Engineering								1,970,000	25	493,000	2,460,000
	1.4.3.4.3.2	Construction								7,840,000	25	1,960,000	9,800,000
	1.4.3.4.3.3	Project Management								590,000	45	266,000	856,000
<b>4.3.4.3</b>	<b>1.4.3.4.3</b>	<b>Total</b>								<b>10,400,000</b>		<b>2,720,000</b>	<b>13,100,000</b>

**TABLE 4.14 Emplacement Summary Costs for Mined-Cavity Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
<b>4.3.4.5</b>	<b>1.4.3.4.5.1</b>	<b>Emplacement</b>							
		<b>Direct Costs</b>							
	1.4.3.4.5.1.1	Materials	273,082,688			273,000,000			
	1.4.3.4.5.1.2	Utilities	28,434,858			28,400,000			
	1.4.3.4.5.1.3	Labor		156,600,000		157,000,000			
		Start-up Labor		5,089,500		5,090,000			
		Total Direct Labor		161,689,500		162,000,000			
		Off-site Overhead Labor		19,402,740		19,400,000			
		Total Labor		181,092,240		181,000,000			
	1.4.3.4.5.1.4	Waste Management			402,648	403,000			
		<b>Total</b>				<b>483,000,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>							
	1.4.3.4.5.1.1	Materials				273,000,000	30	81,900,000	355,000,000
	1.4.3.4.5.1.2	Utilities				28,400,000	35	9,940,000	38,300,000
	1.4.3.4.5.1.3	Labor				181,000,000	25	45,300,000	226,000,000
	1.4.3.4.5.1.4	Waste Management				403,000	35	141,000	544,000
<b>4.3.4.5</b>	<b>1.4.3.4.5.1</b>	<b>Total</b>				<b>483,000,000</b>		<b>137,000,000</b>	<b>620,000,000</b>

**TABLE 4.15 Monitoring and Surveillance Summary Costs for Mined-Cavity Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
4.3.4.5	1.4.3.4.5.2	Monitoring and Surveillance							
		Direct Costs							
	1.4.3.4.5.2.1	Materials	260,277,348			260,000,000			
	1.4.3.4.5.2.2	Utilities	28,041,758			28,000,000			
	1.4.3.4.5.2.3	Labor		92,600,000		92,600,000			
		Off-site Overhead Labor		11,100,000		11,100,000			
	1.4.3.4.5.2.4	Waste Management			18,366	18,400			
		Total				392,000,000			
		Process Facilities Spread by CER Sec. No. (WBS)							
	1.4.3.4.5.2.1	Materials				260,000,000	30	78,000,000	338,000,000
	1.4.3.4.5.2.2	Utilities				28,000,000	35	9,800,000	37,800,000
	1.4.3.4.5.2.3	Labor				104,000,000	25	26,000,000	130,000,000
	1.4.3.4.5.2.4	Waste Management				18,400	35	6,440	24,800
4.3.4.5	1.4.3.4.5.2	Total				392,000,000		114,000,000	506,000,000

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**APPENDIX A:**  
**MORE EFFICIENT STORAGE IN BUILDINGS**



## **APPENDIX A:**

### **MORE EFFICIENT STORAGE IN BUILDINGS**

The main body of this report presents the option of storing the boxes of depleted uranium metal in aboveground buildings that would be 271 m (890 ft) long, 50 m (164 ft) wide, and 5 m (16 ft) high. It was assumed that the wood boxes would be stored on pallets, four boxes per pallet, with the pallets stacked four high (16 boxes per stack). With these assumptions, eight buildings would be needed to store 602,000 boxes of depleted uranium metal. A major cost of the storage facility is the cost of constructing the storage buildings, and the cost of construction depends strongly on the size of the storage buildings. In the base case, space in the storage buildings is not efficiently utilized, in large part because of the relatively low bulk density of uranium metal in the boxes.

In this appendix, the cost analysis for storage of uranium metal in aboveground buildings is revisited. To use space in storage buildings more efficiently, the bulk density of uranium in storage should be increased. It is assumed that the height of a box is reduced from 12 in. to 8 in.; that the number of billets in a box is increased from 19 to 21; and that pallets are stacked six high instead of four. With these changes, the storage area occupied by a stack of boxes is unchanged; however, the number of billets of depleted uranium in a stack is increased from 304 to 504. This change allows the dimensions of each storage building to be reduced to a length of 168 m, with an unchanged width of 50 m. Further information concerning the proposed packaging design for the depleted uranium metal billets is presented in Appendix E of the Engineering Analysis Report — Uranium Metal.

In the main body of this report, three types of storage enclosures are considered: aboveground buildings, below-grade vaults, and underground mined cavities. In this appendix, only storage in buildings is addressed. As before, three cases are considered — storage of 100%, 50%, and 25% of the depleted uranium metal that was produced from the conversion of depleted UF<sub>6</sub> generated by the U.S. Department of Energy (DOE) prior to July 1993.

The rest of this appendix has the same structure as the main body of the report, except that sections, tables, and figures relating to storage in vaults or mined cavities are deleted. The headings of sections that are unchanged are retained and the numbering of remaining are the same as in the main body of this report.

**TABLE A.2.1 Phase I, WBS Level V, Median Life-Cycle Costs:  
Building Storage of Uranium Metal**

Sec.	WBS	Category	Cost in \$ million (1996)
4.1.1	1.4.1.4.1	Equipment	6
4.1.2	1.4.1.4.2	Facilities	214
4.1.3	1.4.1.4.3	Site	15
4.1.4	1.4.1.4.4	Regulatory Compliance	excluded
		<b>Total Phase I Facility Capital Costs</b>	<b>234</b>
4.1.5	1.4.1.4.5	Operations and Maintenance (40.65 years)	442
4.1.6	1.4.1.4.6	Decontamination and Decommissioning	23
		<b>Total Phase I Costs</b>	<b>699</b>

**TABLE A.2.4 Net Present-Value Cost Breakdown for Long-Term Storage of Uranium Metal (\$ million)**

Cost Component	Buildings	Vaults	Mined Cavities	Revised Buildings
<b>Tech. Development</b>	0.82	1.64	3.28	<b>0.82</b>
<b>Equipment</b>				
Engineering	0.53	0.52	0.52	<b>0.50</b>
Fabrication	1.40	1.49	1.52	<b>1.33</b>
Installation	0.88	0.75	0.72	<b>0.83</b>
Certification & Test	0.07	0.07	0.08	<b>0.07</b>
Subtotal	2.88	2.83	2.84	<b>2.72</b>
<b>Facilities</b>				
Engineering	18.68	26.07	46.33	<b>12.87</b>
Construction	77.54	108.18	192.07	<b>52.34</b>
Proj. Management	6.53	9.10	16.07	<b>4.47</b>
Subtotal	102.75	143.35	254.47	<b>69.75</b>
<b>Balance of Plant</b>				
Engineering	1.61	2.01	1.41	<b>1.45</b>
Construction	6.48	8.05	5.61	<b>5.89</b>
Proj. Management	0.56	0.70	0.49	<b>0.51</b>
Subtotal	8.65	10.76	7.51	<b>7.85</b>
<b>Regulatory Compliance</b>	18.61	18.61	18.61	<b>18.61</b>
<b>Operations and Maintenance</b>				
Material	9.90	13.80	119.38	<b>7.97</b>
Utilities	17.61	20.10	12.97	<b>12.24</b>
Labor	63.62	83.01	71.35	<b>61.97</b>
Waste Management & Disposal	0.15	0.15	0.15	<b>0.11</b>
Subtotal	91.28	117.06	203.85	<b>82.56</b>
<b>D&amp;D<sup>a,b</sup></b>	0.00	0.00	0.00	<b>0.00</b>
<b>Total</b>	<b>224.99</b>	<b>294.26</b>	<b>490.56</b>	<b>182.12</b>

<sup>a</sup> To facilitate comparison of the above discounted costs with those presented in the Cost Analysis Report, the D&D costs were set equal to zero in this table.

<sup>b</sup> The D&D costs of the various storage options are as follows:

Building: \$0.98 million  
Vaults: \$1.49 million  
Mined cavity: \$2.35 million  
Revised bldg.: \$0.79 million

**TABLE A.2.5 Nondiscounted Life-Cycle Cost for Each Storage Option (\$ million)**

Type of Storage Enclosures	UF <sub>6</sub>	U <sub>3</sub> O <sub>8</sub>	UO <sub>2</sub>	U-Metal
Aboveground Buildings	782	837	531	874
Below-grade Vaults	----	873	557	1,184
Underground Mined Cavities	2,460	2,830	1,800	1,890
<b>Revised Aboveground Buildings</b>	---	---	---	<b>699</b>

**TABLE A.2.6 Uncertainty Analysis: Cost in \$ Million**

CER Sec. No.	WBS No.	Description	Probability of Overrun				
			90%	75%	50%	25%	10%
Aboveground Storage, Uranium Metal							
4.1.4.1	1.4.1.4.1	Equipment	4	5	6	6	7
	1.4.1.4.1.1	Engineering	1	1	1	1	1
	1.4.1.4.1.2	Fabrication	2	2	3	3	3
	1.4.1.4.1.3	Installation	1	1	2	2	2
	1.4.1.4.1.4	Certification and Test	0	0	0	0	0
4.1.4.2	1.4.1.4.2	Facilities	168	189	214	238	260
	1.4.1.4.2.1	Engineering	31	35	39	43	47
	1.4.1.4.2.2	Construction	126	142	161	180	196
	1.4.1.4.2.3	Project Management	11	12	14	15	17
4.1.4.3	1.4.1.4.3	Site	12	13	15	16	18
	1.4.1.4.3.1	Engineering	2	2	3	3	3
	1.4.1.4.3.2	Construction	9	10	11	12	13
	1.4.1.4.3.3	Project Management	1	1	1	1	1
4.1.4.4	1.4.1.4.4	Operations and Maintenance	321	378	442	506	563
	1.4.1.4.4.1	Emplacement	181	214	251	287	320
	1.4.1.4.4.1.1	Materials	17	21	26	31	36
	1.4.1.4.4.1.2	Utilities	29	32	36	40	43
	1.4.1.4.4.1.3	Labor	135	160	188	216	241
	1.4.1.4.4.1.4	Waste Management	0	0	0	0	0
	1.4.1.4.4.2	Monitoring and Surveillance	139	164	191	218	243
	1.4.1.4.4.2.1	Materials	8	10	12	15	17
	1.4.1.4.4.2.2	Utilities	29	32	36	40	43
	1.4.1.4.4.2.3	Labor	103	122	143	164	183
	1.4.1.4.4.2.4	Waste Management	0	0	0	0	0
	1.4.1.4	Total	504	586	676	766	848

**TABLE A.2.7 Uncertainty Analysis: Factors**

CER Sec. No.	WBS No.	Description	Probability of Overrun				
			90%	75%	50%	25%	10%
Aboveground Storage, Uranium Metal							
4.1.4.1	1.4.1.4.1	Equipment	0.775	0.881	1.000	1.119	1.225
	1.4.1.4.1.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.1.2	Fabrication	0.808	0.899	1.000	1.101	1.192
	1.4.1.4.1.3	Installation	0.705	0.845	1.000	1.155	1.295
	1.4.1.4.1.4	Certification and Test	0.808	0.899	1.000	1.101	1.192
4.1.4.2	1.4.1.4.2	Facilities	0.784	0.886	1.000	1.114	1.216
	1.4.1.4.2.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.2.2	Construction	0.781	0.885	1.000	1.115	1.219
4.1.4.3	1.4.1.4.2.3	Project Management	0.776	0.882	1.000	1.118	1.224
	1.4.1.4.3	Site	0.801	0.895	1.000	1.105	1.199
	1.4.1.4.3.1	Engineering	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.3.2	Construction	0.804	0.897	1.000	1.103	1.196
4.1.4.4	1.4.1.4.3.3	Project Management	0.776	0.882	1.000	1.118	1.224
	1.4.1.4.4	Operations and Maintenance	0.725	0.855	1.000	1.145	1.275
	1.4.1.4.4.1	Emplacement	0.723	0.854	1.000	1.146	1.277
	1.4.1.4.4.1.1	Materials	0.649	0.815	1.000	1.185	1.351
	1.4.1.4.4.1.2	Utilities	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.4.1.3	Labor	0.718	0.852	1.000	1.148	1.282
	1.4.1.4.4.1.4	Waste Management	0.800	0.895	1.000	1.105	1.200
	1.4.1.4.4.2	Monitoring and Surveillance	0.729	0.857	1.000	1.143	1.271
	1.4.1.4.4.2.1	Materials	0.649	0.815	1.000	1.185	1.351
	1.4.1.4.4.2.2	Utilities	0.800	0.895	1.000	1.105	1.200
1.4.1.4.4.2.3	Labor	0.718	0.852	1.000	1.148	1.282	
1.4.1.4.4.2.4	Waste Management	0.800	0.895	1.000	1.105	1.200	
	1.4.1.4	Total	0.746	0.866	1.000	1.134	1.254



**TABLE A.2.8 Phase I, WBS Level V, Life-Cycle Costs by Year: Building Storage of Uranium Metal**

		Construction Costs (\$)										
		Year 1	2	3	4	5	6	7	8	9	10	Subtotal
1.4.1.4.1	Equipment									2,360,000	2,400,000	4,760,000
1.4.1.4.1.1	Engineering									432,000	439,000	871,000
1.4.1.4.1.2	Fabrication									1,160,000	1,180,000	2,340,000
1.4.1.4.1.3	Installation									711,000	726,000	1,440,000
1.4.1.4.1.4	Certification and Test									58,100	59,000	117,000
1.4.1.4.2	Facility									17,000,000	26,000,000	43,000,000
1.4.1.4.2.1	Engineering									3,300,000	4,930,000	8,230,000
1.4.1.4.2.2	Construction									12,500,000	19,300,000	31,800,000
1.4.1.4.2.3	Project Management									1,150,000	1,720,000	2,870,000
1.4.1.4.3	Site									11,000,000	3,670,000	14,700,000
1.4.1.4.3.1	Engineering									2,030,000	678,000	2,710,000
1.4.1.4.3.2	Construction									8,250,000	2,750,000	11,000,000
1.4.1.4.3.3	Project Management									711,000	237,000	948,000
1.4.1.4.5	O&M										5,920,000	5,920,000
1.4.1.4.5.1	Emplacement										5,920,000	5,920,000
1.4.1.4.5.1.1	Materials											
1.4.1.4.5.1.2	Utilities											
1.4.1.4.5.1.3	Labor										5,920,000	5,920,000
1.4.1.4.5.1.4	Waste Management											
1.4.1.4.5.2	Monitoring and Surveillance											
1.4.1.4.5.2.1	Materials											
1.4.1.4.5.2.2	Utilities											
1.4.1.4.5.2.3	Labor											
1.4.1.4.5.2.4	Waste Management											
1.4.1.4.6	D&D											
	Total Cost									30,400,000	38,000,000	68,400,000

**TABLE A.2.8 (Cont.)**

		Emplacement Costs (\$)										Subtotal
		Year 11	12	13	14	15	16	17	18	19	20	
1.4.1.4.1	Equipment	41,900	41,900	41,900	41,900	41,900	41,900	41,900	41,900	41,900	41,900	5,180,000
1.4.1.4.1.1	Engineering	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	944,000
1.4.1.4.1.2	Fabrication	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	2,530,000
1.4.1.4.1.3	Installation	14,900	14,900	14,900	14,900	14,900	14,900	14,900	14,900	14,900	14,900	1,590,000
1.4.1.4.1.4	Certification and Test	940	940	940	940	940	940	940	940	940	940	126,000
1.4.1.4.2	Facility	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	133,000,000
1.4.1.4.2.1	Engineering	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	24,500,000
1.4.1.4.2.2	Construction	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	99,800,000
1.4.1.4.2.3	Project Management	565,000	565,000	565,000	565,000	565,000	565,000	565,000	565,000	565,000	565,000	8,520,000
1.4.1.4.3	Site											14,700,000
1.4.1.4.3.1	Engineering											2,710,000
1.4.1.4.3.2	Construction											11,000,000
1.4.1.4.3.3	Project Management											948,000
1.4.1.4.5	O&M	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	129,000,000
1.4.1.4.5.1	Emplacement	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	129,000,000
1.4.1.4.5.1.1	Materials	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	13,200,000
1.4.1.4.5.1.2	Utilities	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	18,100,000
1.4.1.4.5.1.3	Labor	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	96,900,000
1.4.1.4.5.1.4	Waste Management	20,500	20,500	20,500	20,500	20,500	20,500	20,500	20,500	20,500	20,500	205,000
1.4.1.4.5.2	Monitoring and Surveillance											
1.4.1.4.5.2.1	Materials											
1.4.1.4.5.2.2	Utilities											
1.4.1.4.5.2.3	Labor											
1.4.1.4.5.2.4	Waste Management											
1.4.1.4.6	D&D											
	Total Cost	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	281,000,000

**TABLE A.2.8 (Cont.)**

		Emplacement Costs (\$) (Cont.)										Subtotal
		Year 21	22	23	24	25	26	27	28	29	30	
1.4.1.4.1	Equipment	41,900	41,900	41,900	41,900	41,900	41,900	41,900	41,900	41,900		5,560,000
1.4.1.4.1.1	Engineering	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300		1,010,000
1.4.1.4.1.2	Fabrication	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800	18,800		2,700,000
1.4.1.4.1.3	Installation	14,900	14,900	14,900	14,900	14,900	14,900	14,900	14,900	14,900		1,720,000
1.4.1.4.1.4	Certification and Test	940	940	940	940	940	940	940	940	940		134,000
1.4.1.4.2	Facility	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000	9,000,000		214,000,000
1.4.1.4.2.1	Engineering	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000	1,630,000		39,200,000
1.4.1.4.2.2	Construction	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000	6,800,000		161,000,000
1.4.1.4.2.3	Project Management	565,000	565,000	565,000	565,000	565,000	565,000	565,000	565,000	565,000		13,600,000
1.4.1.4.3	Site											14,700,000
1.4.1.4.3.1	Engineering											2,710,000
1.4.1.4.3.2	Construction											11,000,000
1.4.1.4.3.3	Project Management											948,000
1.4.1.4.5	O&M	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	252,000,000
1.4.1.4.5.1	Emplacement	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	12,300,000	252,000,000
1.4.1.4.5.1.1	Materials	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	1,320,000	26,400,000
1.4.1.4.5.1.2	Utilities	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	1,810,000	36,200,000
1.4.1.4.5.1.3	Labor	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	9,100,000	188,000,000
1.4.1.4.5.1.4	Waste Management	20,500	20,500	20,500	20,500	20,500	20,500	20,500	20,500	20,500	20,500	410,000
1.4.1.4.5.2	Monitoring and Surveillance											
1.4.1.4.5.2.1	Materials											
1.4.1.4.5.2.2	Utilities											
1.4.1.4.5.2.3	Labor											
1.4.1.4.5.2.4	Waste Management											
1.4.1.4.6	D&D											
	Total Cost	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	21,300,000	12,300,000	485,000,000

**TABLE A.2.8 (Cont.)**

		Surveillance and Monitoring Costs (\$) (Cont.)										Subtotal
		Year 31	32	33	34	35	36	37	38	39	40	
1.4.1.4.1	Equipment											5,560,000
1.4.1.4.1.1	Engineering											1,010,000
1.4.1.4.1.2	Fabrication											2,700,000
1.4.1.4.1.3	Installation											1,720,000
1.4.1.4.1.4	Certification and Test											134,000
1.4.1.4.2	Facility											214,000,000
1.4.1.4.2.1	Engineering											39,200,000
1.4.1.4.2.2	Construction											161,000,000
1.4.1.4.2.3	Project Management											13,600,000
1.4.1.4.3	Site											14,700,000
1.4.1.4.3.1	Engineering											2,710,000
1.4.1.4.3.2	Construction											11,000,000
1.4.1.4.3.3	Project Management											948,000
1.4.1.4.5	O&M	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	348,000,000
1.4.1.4.5.1	Emplacement											252,000,000
1.4.1.4.5.1.1	Materials											26,400,000
1.4.1.4.5.1.2	Utilities											36,200,000
1.4.1.4.5.1.3	Labor											188,000,000
1.4.1.4.5.1.4	Waste Management											410,000
1.4.1.4.5.2	Monitoring and Surveillance	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	95,600,000
1.4.1.4.5.2.1	Materials	620,000	620,000	620,000	620,000	620,000	620,000	620,000	620,000	620,000	620,000	6,200,000
1.4.1.4.5.2.2	Utilities	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	17,900,000
1.4.1.4.5.2.3	Labor	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	71,500,000
1.4.1.4.5.2.4	Waste Management	950	950	950	950	950	950	950	950	950	950	9,500
1.4.1.4.6	D&D											
	Total Cost	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	581,000,000

**TABLE A.2.8 (Cont.)**

		Surveillance and Monitoring Costs (\$) (Cont.)										Subtotal
		Year 41	42	43	44	45	46	47	48	49	50	
1.4.1.4.1	Equipment											5,560,000
1.4.1.4.1.1	Engineering											1,010,000
1.4.1.4.1.2	Fabrication											2,700,000
1.4.1.4.1.3	Installation											1,720,000
1.4.1.4.1.4	Certification and Test											134,000
1.4.1.4.2	Facility											214,000,000
1.4.1.4.2.1	Engineering											39,200,000
1.4.1.4.2.2	Construction											161,000,000
1.4.1.4.2.3	Project Management											13,600,000
1.4.1.4.3	Site											14,700,000
1.4.1.4.3.1	Engineering											2,710,000
1.4.1.4.3.2	Construction											11,000,000
1.4.1.4.3.3	Project Management											948,000
1.4.1.4.5	O&M	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	444,000,000
1.4.1.4.5.1	Emplacement											252,000,000
1.4.1.4.5.1.1	Materials											26,400,000
1.4.1.4.5.1.2	Utilities											36,200,000
1.4.1.4.5.1.3	Labor											188,000,000
1.4.1.4.5.1.4	Waste Management											410,000
1.4.1.4.5.2	Monitoring and Surveillance	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	191,000,000
1.4.1.4.5.2.1	Materials	620,000	620,000	620,000	620,000	620,000	620,000	620,000	620,000	620,000	620,000	12,400,000
1.4.1.4.5.2.2	Utilities	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	1,790,000	35,800,000
1.4.1.4.5.2.3	Labor	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	7,150,000	143,000,000
1.4.1.4.5.2.4	Waste Management	950	950	950	950	950	950	950	950	950	950	19,000
1.4.1.4.6	D&D										23,400,000	23,400,000
	Total Cost	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	9,560,000	33,000,000	700,000,000

**TABLE A.4.1 Equipment Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
									(%)	(\$)	
<b>4.1.4.1</b>	<b>1.4.1.4.1</b>	<b>Equipment</b>		<b>1,784,561</b>	<b>108,818</b>	<b>362,000</b>	<b>107,074</b>	<b>2,360,000</b>			
		Initial Spares	10% of equipment	178,456			<b>10,707</b>	<b>189,000</b>			
		<b>Total Direct Costs</b>		<b>1,963,017</b>	<b>108,818</b>	<b>362,000</b>	<b>117,781</b>	<b>2,550,000</b>			
		Distributable Field Costs	28% of DL for mat'l	30,469			1,828	32,300			
			75% of DL \$		81,614			81,600			
		Contractor's Overhead	5% of materials and subcntrct	98,151		18,100	5,889	122,000			
		and Profit	15% of DL \$		28,565			28,600			
		<b>Subtotal Contractor's Costs</b>		<b>2,091,637</b>	<b>218,997</b>	<b>380,100</b>	<b>125,498</b>	<b>2,810,000</b>			
		Contractor's Bond	1% of total contractor's cost					28,100			
		<b>Total Contractor's Field Cost</b>						<b>2,840,000</b>			
		Construction Management	10% of contractor's field cost					284,000			
		<b>Total Field Costs</b>						<b>3,120,000</b>			
		A/E Costs	25% of total field costs					780,000			
		<b>Subtotal</b>						<b>3,900,000</b>			
		Program Management	6% of subtotal costs					234,000			
		<b>Total</b>						<b>4,130,000</b>			
	<b>1.4.1.4.1</b>	<b>Equipment: Spread by CER Sec. No. (WSS)</b>									
	1.4.1.4.1.1	Engineering						780,000	30	234,000	1,010,000
	1.4.1.4.1.2	Fabrication						2,080,000	30	624,000	2,700,000
	1.4.1.4.1.3	Installation						1,270,000	35	445,000	1,720,000
	1.4.1.4.1.4	Certification and Test						104,000	30	31,200	135,000
<b>4.1.4.1</b>	<b>1.4.1.4.1</b>	<b>Total</b>						<b>4,230,000</b>		<b>1,330,000</b>	<b>5,570,000</b>

**TABLE A.4.2 Facility Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Unit	Hours	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
<b>4.1.4.2</b>	<b>1.4.1.4.2</b>	<b>Facilities</b>											
		Storage Buildings	723,405	sf	606,854	29,067,923	19,903,551	14,806,213	1,744,075	65,500,000			
		Rec Ware & Repackage	67,012	sf	169,097	4,934,938	5,384,343	1,234,447	296,096	11,800,000			
		<b>Total Direct Costs</b>				<b>34,002,861</b>	<b>25,287,894</b>	<b>16,040,660</b>	<b>2,040,172</b>	<b>77,300,000</b>			
		Distributable Field Costs	28% of DL for mat'l			7,080,610			424,837	7,510,000			
			75% of DL \$				18,965,921			19,000,000			
		Contractor's Overhead	5% of materials and subcont			1,700,143		802,033	102,009	2,600,000			
		and Profit	15% of DL \$				6,638,072			6,640,000			
		<b>Subtotal Contractor's Costs</b>				<b>42,783,614</b>	<b>50,891,887</b>	<b>16,842,693</b>	<b>2,567,017</b>	<b>113,000,000</b>			
		Contractor's Bond	1% of total contractor's cost							1,130,000			
		<b>Total Contractor's Field Cost</b>								<b>114,000,000</b>			
		Construction Management	10% of contractor's field cost							11,400,000			
		<b>Total Field Costs</b>								<b>125,000,000</b>			
		A/E Costs	25% of total field costs							31,300,000			
		<b>Subtotal</b>								<b>156,000,000</b>			
		Program Management	6% of subtotal costs							9,360,000			
		<b>Total</b>								<b>165,000,000</b>			
		<b>Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.1.4.2.1	Engineering								31,300,000	25	7,830,000	39,100,000
	1.4.1.4.2.2	Construction								124,000,000	30	37,200,000	161,000,000
	1.4.1.4.2.3	Project Management								9,360,000	45	4,210,000	13,600,000
<b>4.1.4.2</b>	<b>1.4.1.4.2</b>	<b>Total</b>								<b>165,000,000</b>		<b>49,200,000</b>	<b>214,000,000</b>

**TABLE A.4.3 Site Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Quantity	Unit	Hours	Materials (\$)	Labor (\$)	S/C (\$)	Tax on Mat'l 6% (\$)	Subtotal (\$)	Contingency		Total (\$)
											(%)	(\$)	
<b>4.1.4.3</b>	<b>1.4.1.4.3</b>	<b>Site</b>											
		<b>Direct Costs</b>											
		Site Improvements and Utilities				1,301,212	1,010,948	480,165	78,073	2,870,000			
		<b>Equipment</b>											
		Yard Mobile Equipment				340,000			20,400	360,000			
		<b>Support Buildings</b>											
		Administration Building	7,266	sf	15,508	624,603	470,025	1,324	37,476	1,130,000			
		Workshop	6,728	sf	7,336	706,772	252,039	1,226	42,406	1,000,000			
		<b>Total Direct Costs</b>				<b>2,972,587</b>	<b>1,733,012</b>	<b>482,715</b>	<b>178,355</b>	<b>5,360,000</b>			
		Distributable Field Costs	28% of DL for mat'l			485,243			29,115	514,000			
			75% of DL \$					1,299,759		1,300,000			
		Contractor's Overhead	5% of materials and subentrc			159,275		148,629	8,918	182,000			
		and Profit	15% of DL \$					454,916		455,000			
		<b>Subtotal Contractor's Costs</b>				<b>3,606,460</b>	<b>3,487,687</b>	<b>506,851</b>	<b>216,388</b>	<b>7,810,000</b>			
		Contractor's Bond	1% of total contractor's cost							78,100			
		<b>Total Contractor's Field Cost</b>								<b>7,890,000</b>			
		Construction Management	10% of contractor's field cost							789,000			
		<b>Total Field Costs</b>								<b>8,680,000</b>			
		A/E Costs	25% of total field costs							2,170,000			
		<b>Subtotal</b>								<b>10,900,000</b>			
		Program Management	6% of subtotal costs							654,000			
		<b>Total</b>								<b>11,600,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>											
	1.4.1.4.3.1	Engineering								2,170,000	25	543,000	2,710,000
	1.4.1.4.3.2	Construction								8,776,000	25	2,190,000	11,000,000
	1.4.1.4.3.3	Project Management								654,000	45	294,000	948,000
<b>4.1.4.3</b>	<b>1.4.1.4.3</b>	<b>Total</b>								<b>11,600,000</b>		<b>3,030,000</b>	<b>14,700,000</b>



**TABLE A.4.4 Emplacement Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
<b>4.1.4.5</b>	<b>1.4.1.4.5.1</b>	<b>Emplacement Direct Costs</b>							
	1.4.1.4.5.1.1	Materials	20,200,000			20,200,000			
	1.4.1.4.5.1.2	Utilities	26,700,000			26,700,000			
	1.4.1.4.5.1.3	Labor		130,000,000		130,000,000			
		Start-up Labor		4,210,000		4,210,000			
		<b>Direct Labor</b>		<b>134,000,000</b>		<b>134,000,000</b>			
		Off-site Overhead Labor		16,100,000		16,100,000			
		<b>Total Labor</b>		<b>150,000,000</b>		<b>150,000,000</b>			
	1.4.1.4.5.1.4	Waste Management			304,000	304,000			
		<b>Total</b>				<b>197,000,000</b>			
		<b>Process Facilities Spread by CER Sec. No. (WBS)</b>							
	1.4.1.4.5.1.1	Materials				20,200,000	30	6,060,000	26,300,000
	1.4.1.4.5.1.2	Utilities				26,700,000	35	9,350,000	36,100,000
	1.4.1.4.5.1.3	Labor				150,000,000	25	37,500,000	188,000,000
	1.4.1.4.5.1.4	Waste Management				304,000	35	106,000	410,000
<b>4.1.4.5</b>	<b>1.4.1.4.5.1</b>	<b>Total</b>				<b>197,000,000</b>		<b>53,000,000</b>	<b>251,000,000</b>

**TABLE A.4.5 Monitoring and Surveillance Summary Costs for Building Storage of Uranium Metal**

CER Sec. No.	WBS	Facilities/Cost Items	Materials (\$)	Labor (\$)	S/C (\$)	Subtotal (\$)	Contingency		Total (\$)
							(%)	(\$)	
4.1.4.5	1.4.1.4.5.2	Monitoring and Surveillance							
		Direct Costs							
	1.4.1.4.5.2.1	Materials	9,530,000			9,530,000			
	1.4.1.4.5.2.2	Utilities	26,500,000			26,500,000			
	1.4.1.4.5.2.3	Labor		102,000,000		102,000,000			
		Off-site Overhead Labor		12,200,000		12,200,000			
	1.4.1.4.5.2.4	Waste Management			14,100	14,100			
		Total				150,000,000			
		Process Facilities	Spread by CER Sec. No. (WBS)						
	1.4.1.4.5.2.1	Materials				9,530,000	30	2,860,000	12,400,000
	1.4.1.4.5.2.2	Utilities				26,500,000	35	9,280,000	35,800,000
	1.4.1.4.5.2.3	Labor				114,000,000	25	28,500,000	143,000,000
	1.4.1.4.5.2.4	Waste Management				14,100	35	4,930	19,000
4.1.4.5	1.4.1.4.5.2	Total				150,000,000		40,600,000	191,000,000